

CHEMICAL FIRE EXTINGUISHERS  
OF SODA AND ACID TYPE

BY

N. F. KIMBALL

ARMOUR INSTITUTE OF TECHNOLOGY  
1920

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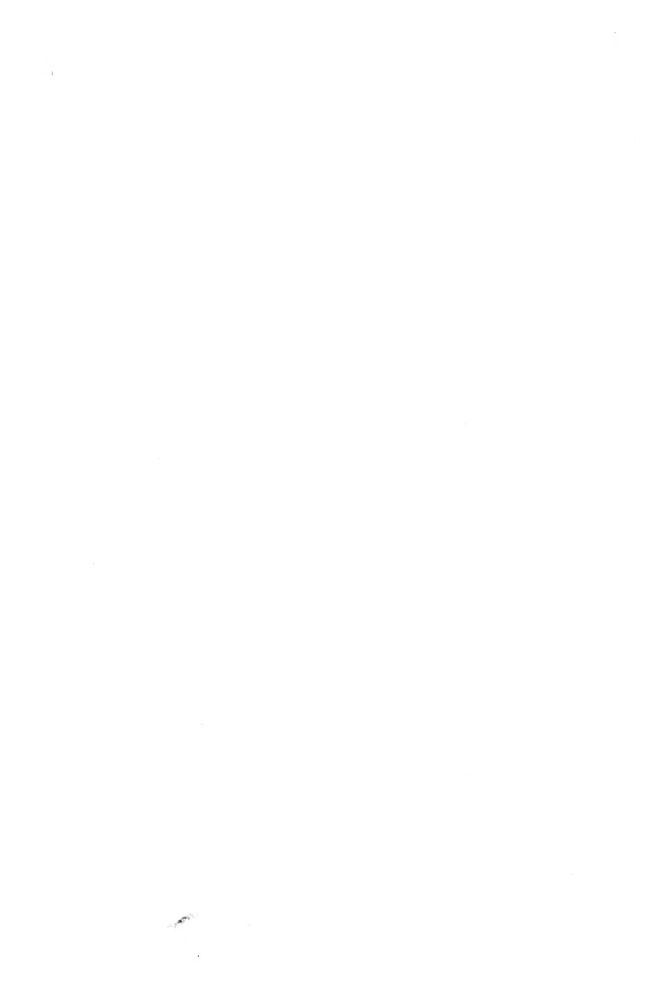
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Fire extinguishing  
efficiency of chemical fire

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FIRE EXTINGUISHING EFFICIENCY OF  
CHEMICAL FIRE EXTINGUISHERS  
OF SODA AND ACID TYPE

A THESIS

PRESENTED BY

NORMAN FRANK KIMBALL

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

FIRE PROTECTION ENGINEER

MAY 31, 1920

APPROVED:

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## A C K N O W L E D G M E N T

The author is indebted to the O.J. Childs Company of Utica, N.Y. for the apparatus used in the tests; to Professor Herman Diederichs, head of the Experimental Engineering Department of Sibley College at Cornell University, and Assistant Professors Robertson Matthews and A.C. Davis for their aid in the performance of the tests; and to Mr. Dan S. Hunter, Secretary of the Fire Extinguisher Exchange for data gathered from City Fire Department Chiefs.



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## I N T R O D U C T I O N

Chemical fire extinguishers employing sodium bicarbonate and sulphuric acid were first introduced about fifty years ago. At first the machines were rather crude but were later developed until the present type of two- and-one-half gallon machine has become the standard extinguisher and is largely used for the protection of private property.

During the past few years small one-quart extinguishers of the pump type using carbon tetrachloride, either pure, or mixed with other substances have been developed. These one quart extinguishers are particularly efficient in dealing with grease, fires, oil or gasoline fires, or electrical fires, where the application of water may be very undesirable.

Because of their wide range of usefulness and their almost universal use, the soda- and- acid extinguisher is taken as the subject of this thesis. These ordinary extinguishers are generally termed as three gallon machines by the manufacturers, three gallons being the total capacity; and as two- and-one



half gallon machines by Underwriters' Laboratories, two- and one-half gallons being the liquid capacity.

An extensive series of tests to determine the fire extinguishing efficiency of three gallon chemical fire extinguishers was conducted by the writer and several members of the faculty at Sibley College of Cornell University at Ithaca, New York. This series of tests and the results obtained are taken as the subject of this thesis.





## THREE GALLON CHEMICAL FIRE EXTINGUISHERS.

### DESCRIPTION

The soda- and- acid chemical fire extinguisher consists essentially of an outer cylindrical copper container closed by means of a cap which threads on to a collar surrounding the charging aperture. The container is partially filled with a solution of water and bicarbonate of soda. A glass bottle is supported in a cage at the upper end of the tank, contains a small quantity of sulphuric acid, and is fitted with a loose lead stopple. A short length of rubber hose fitted with a nozzle, is attached to a discharge elbow.

The operation of a soda- and-acid extinguisher is as follows: When the extinguishers is turned upside down, the loose-fitting stopple drops away from the mouth of the acid bottle, allowing the sulphuric acid to flow from the bottle and mix with the soda solution. The resulting chemical reaction liberates carbon dioxide acid gas. This gas generates comparatively high pressures, which the container is designed to withstand. This pressure propels the liquid with great force through the discharge elbow



into the hose and cut through the nozzle.

It can be seen from the above, that a chemical fire extinguisher of the soda-and-acid type is a self-contained unit. Normally, it stands without being under pressure, but just as soon as it is operated it generates its own pressure and discharges a stream from thirty to forty feet.

#### CONSTRUCTION

The accompanying photograph shows a "Childs" two-and-one-half gallon soda and acid fire extinguisher which is labeled and approved by the Underwriters' Laboratories.

The tank or shell of the "Childs" extinguisher is made of No. 18 B & S gauge cold rolled Lake Superior Copper. The sheet is rolled and the longitudinal seam is riveted with copper rivets, and then sweated and floated with solder. The top and bottom of the device is pressed into shape from circles of No. 16 B & S copper. The top is riveted to the shell and the joint is then sweated and floated with solder. The bottom is supported by a heavy bead and is further reinforced by a banking of solder. The interior of

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the extinguisher is heavily and evenly coated with lead-tin alloy.

The opening in the tank through which the chemicals are placed is located in the top or dome. This opening is surrounded by a threaded brass collar which is soldered to the inside of the tank head. The opening is closed by means of a brass cap which threads on to the collar in such a way that the threads are protected from the chemicals in the tank. A ring handle is cast integral with the cap to facilitate removal and replacement.

A short length of one-half inch four-ply red rubber chemical hose is attached at one end to a discharge elbow, which is of brass and soldered to the dome of the tank. The entrance to the discharge elbow is protected by a perforated copper strainer to prevent foreign matter from clogging the nozzle. The opposite end of the hose is fitted with a nozzle cast of composition metal.

The acid bottle is of glass with a flanged neck and is supported in a brass wire cage which is attached to the under surface of the cap. The bottle is fitted



with a loose stopple of composition metal having a stem which extends down into the neck of the bottle and limits the rate of acid feed when the extinguisher is inverted.

The directions for operating, charging, and maintaining the extinguisher are clearly given on an embossed brass plate which is soldered on the front of the tank.

## STRENGTH

In order to calculate the bursting pressures, factors of safety involved, and the like is necessary and of interest to first analyze the more important stresses in a 3-gallon soda and acid extinguisher.

The longitudinal tension stress in the shell of a thin hollow cylinder closed at the ends and subjected to internal pressure is:

$$T_1 = \frac{PD}{2t} \dots \dots \dots (1)$$

Where

T.= Axial tension stress in lbs per sq. In.

P.= Internal pressure in lbs per Sq.In.

D.= Internal diameter in inches

t.= Thickness of shell in inches





The transverse tension stress is given by the formula:

$$T_2 = \frac{PD}{4t} \dots \dots \dots (2)$$

where the notation is the same as before.

These two stresses act at right angles to each other and the true stress in the material is, therefore, given by:

$$\begin{aligned} T &= T_1 - X T_2 \\ &= T_1 - T_2 \frac{2}{3} \\ &= T_1 - T_1 \frac{2}{3} \quad \left( \text{Since } T_2 = \frac{T_1}{3} \right) \\ &= \frac{5}{6} T_1 \\ &= \frac{5}{12} \frac{PD}{t} \dots \dots \dots (3) \end{aligned}$$

In the above X is Poisson's ratio which for hard copper or for steel is approximately 1/3.

A stress in any direction produces a strain (deformation) in that direction as well as a strain at right angles to that direction. The ratio of the strain at right angles to the force of the strain in the direction of the force is known as Poisson's ratio.

For the stress in the bottom or dome, both of which and especially the former are approximately



spherical in shape, the following applies:

$$T_1 = \frac{PR}{2t} \dots \dots \dots (4)$$

Where

$T_1$  = Apparent stress in lbs. per sq. in.

P = Internal Pressure in lbs per sq. in.

R = Radius of curvature, inches

t = Thickness, inches

Since at any point in the spherical portion there are two tensional stresses acting at right angles to each other and of equal magnitude, the true stress is given by the following:

$$\begin{aligned} T &= T_1 - X T_1 \\ &= \frac{PR}{2t} - 1/3 \frac{PR}{2t} \\ &= \frac{PR}{3t} \dots \dots \dots (5) \end{aligned}$$

The tensile strength of pure copper which has been cast, rolled and drawn, followed by annealing for one-half to one hour at about 500° centigrade and then by slow or quick cooling, is given by the United States Bureau of Standards as 35000  $\pm$  5000 lbs persq. in. In the condition outlined above pure copper has no elastic or proportional limit, i.e., the ordinary methods of determining such quantities yield no value for this material.

Kent in his Mechanical Engineers Handbook gives



for the tensile strength of sheet copper 30,470 to 48,450 lbs. per. sq. inch depending on the treatment and condition. Kent also states the results of some of Kirkalyd's tests as follows: Results of 22 tests on rolled copper plates 0.260 inch to 0.750 inch thick; elastic limit 9766 to 18,650 lbs. per. sq. in., and the tensile strength 30, 993 to 34, 281 lbs. per. sq. in. The great variation in elastic limit is said to be due to difference in the finishing conditions. He further states that annealing reduces the tensile strength by about 1000 lbs. per sq. in., while it reduces the elastic limit from 3000 to 7000 pounds per square inch.

From the foregoing data, it will be noted that the tensile strength of copper in the form of a sheet may be about 30,000 to 35,000 lbs. per. sq.in., and that it has a very indefinite elastic limit(if any) depending on its condition. Cold reduction raises its ultimate strength remarkably and also gives it an elastic limit or limit of proportionality. A conservative value for ultimate tensile strength for



the sheet copper used in a chemical fire extinguisher is 35,000 lbs. per. sq. in. and this value will be used in the following calculations.

Tests undicate that under normal conditions of charge and temperature,  $2\frac{1}{2}$  gallons of water,  $1\frac{1}{2}$  pounds of soda, 4 ounces of acid, and solution temperature of 70 ° Fahrenheit the maximum pressure attained during operation is 90 to 95 lbs. per. sq. in. If the temperature is 90 ° Fahrenheit the maximum may be 100 to 105 pounds. Hence for the purpose of calculation a pressure of 100 pounds is assumed as a normal working pressure.

Tests made with closed nozzle and excessive charges have shown that pressures as high as 450 pounds per square inch could be produced. A normal charge and a closed nozzle may show a maximum of 200 lbs. per. sq. in.

The true stress in the shell may be calculated by the use of formula (3),  $T = 5/12 \frac{PD}{t}$

Assume

$$P = 100 \text{ lbs. per. sq. in.}$$

$$D = 7 \text{ inches}$$





$t = .040$  inch (# 18 B & S gauge)

Then  $T$  is 7290 lbs. per. sq. in., with a tensile strength of 35,000 lbs. per. sq. in., this represents a factor of safety of 4.8.

At a pressure of 350 lbs. per. sq. in., the pressure at which extinguishers are tested at the factory before being shipped, the stress would be 25, 500 lbs. per. sq. in. As these extinguishers withstand this pressure for 1 minute without permanent distortion the elastic limit or, more accurately, the limit of proportionality must be at or slightly above this figure.

By the same formula, the stress at failure would be 480 lbs. per. sq. in.

Aside from the thickness of the material in the bottom, the radius of curvature of the spherical portion and that of the flange are very important in the case of a dished head. The calculation of the stresses in "dished" ends for cylindrical shells is a difficult matter owing to the uncertainty of distribution caused by the necessity for a shortened radius of curvature where the spherical portion joins



the cylindrical shell. Such a head is a compromise between a flat head( which would require staying) . and a hemi- spherical head ( which would not require staying). Any shape other than a hemi- sphere tends to become hemi- spherical under pressure and accordingly, there may be a very irregular stress distribution owing to bending moments set up by the tendency to change of curvature.

In calculating the stress in the material of the bottom of 2 2½ gallon fire extinguisher, it will be assumed that the spherical portion forms part of a complete sphere. In this case formula (5) may be used to get an estimate of the true stress. Formula (40 is frequently used in this connection but gives the apparent stress since it assumes the material to be under simple tensile stress, whereas, a compound stress exists. Using (5) and substituting:

$$P = 100 \text{ lbs. per. sq. in.}$$

$$R = 5 \text{ Inches}$$

$$t = .050 \text{ inch (\# 16 B \& S Gauge)}$$

We have

$$T = \frac{100 \times 5}{3 \times .050} = 3330 \text{ lbs. per. sq. in.}$$

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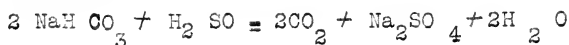


This would indicate that there is a factor of safety of 35,000 divided by 3330 or 10.5.

The stress in the bottom near the flange might exceed 3330 lbs. per. sq. in., depending on the form or curve used. However, the material at this place is usually much stronger on account of the cold work done on it during forming and although the stress might be higher the factor of safety is still large enough for all purposes. In addition to cold working, the solder backing offers an extra support. The soldering process may remove some of the beneficial effects of the cold working.

#### QUANTITATIVE ANALYSIS OF EXTINGUISHING LIQUID IN SODA AND ACID EXTINGUISHERS.

The theoretical chemical reaction that occurs in a chemical fire extinguisher of the soda and acid type is as follows:



In this reaction, according to the molecular weights, 168.12 parts of sodium bicarbonate react with 98.08 parts of sulphuric acid to produce 142.16 parts of sodium sulphate, 98 parts of carbon dioxide and 36 parts of water.



Four fluid ounces of the 68 deg Beume acid weighs 216.9 grams, but since this acid is only 93.19 % sulphuric acid, the actual amount of sulphuric acid used is equivalent to 202.1 grams. It may be assumed that the balance of the acid is water, amounting to 14.8 grams.

The one and one-half pounds of sodium bicarbonate are equivalent to 680.4 grams. In the above reaction the 202.1 grams of sulphuric acid react with 346.4 grams of sodium bicarbonate, leaving 334.0 grams of sodium bicarbonate unacted upon. With these amounts of soda and acid in reaction the products formed are as follows:

392.9 grams of sodium sulphate

181.3 grams of carbon dioxide

74.3 grams of water

The  $2\frac{1}{2}$  gallons of water originally put into the extinguisher are equivalent to 9463.6 grams.

Summarizing, the following are put into the extinguisher,

202.1 grams of sulphuric acid

680.4 grams of sodium bicarbonate

9463.6 grams of water

14.8 grams of water ( Which is in the acid)

-----  
10,360.9 grams Total





From these results, the stream contains the following constituents by weight:-

2.93 %	sodium sulphate
1.75%	carbon dioxide
3.22 %	sodium bicarbonate
92.20 %	water
-----	
100.0 %	Total

Converting the values given in grams to ounces and gallons the following are discharged from the  $3\frac{1}{2}$  gallon soda and acid extinguisher containing a standard charge:

10.33	ounces	sodium sulphate
6.40	ounces	carbon dioxide
11.78	ounces	sodium bicarbonate
$2\frac{1}{2}$	gallons	water
$\frac{1}{2}$	fluid ounce	water ( which was in the acid)
$2\frac{1}{2}$	fluid ounces	water ( formed in reaction)

USE

Three gallon soda and acid chemical fire extinguishers are recommended for use on incipient fires.

These chemical fire extinguishers are effective upon all fires in structural materials and upon fires in ordinary stocks of merchandise, whether classed as



hazardous, nonhazardous, or extra hazardous, upon all ordinary furniture, machinery, and containers for merchandise. In textile and flour mills, grain elevators, woodworkers(except in special rooms) and upon fires in all substances that mix with water. They are especially suited for fires above floor levels.

These devices are not effective upon fires in liquids that do not mix or combine with water, such as oils, grease, gasoline, etc., nor upon calcium carbide, sodium and potassium nitrates, and oxygen carriers in general, sulphuric and muriatic acids, tar, pitch, asphalt and rosin. They are of doubtful efficiency if applied directly to piles of finely divided combustible matter such as fine sawdust, flour mill and elevator dust.

#### UNDERWRITERS' LABORATORIES CLASSIFICATION

Extinguishers of loose stopple and break bottle types using soad and acid are effective on incipient fires in free burning material ( such as wood, etc.) and where water or solutions containing large percentages of water are effective. They are of limited



service on fires in liquids of a flammable nature. Their use on electric arcs, electric machinery or wiring carrying high voltages may be dangerous on account of conductivity of the liquid. They must be protected from freezing.



I N V E S T I G A T I O N   O F   F I R E  
E X T I N G U I S H I N G   E F F I C I E N C Y  
O F   C H E M I C A L   F I R E E X T I N G U I S H E R S  
O F   S O D A   A N D   A C I D   T Y P E

PURPOSE OF INVESTIGATION

The purpose of this investigation was to determine the relative fire extinguishing efficiency of the stream discharged from an ordinary two-and-one-half gallon chemical fire extinguisher of the soda- and-acid type as compared with equal amounts of plain water applied in the same manner. In other words, to ascertain whether the carbonic acid gas generated in the extinguisher as well as the salts present in the solution have any effect in quenching a fire; or whether the gas simply acts to propel the water contained in the extinguisher and in this way possesses no marked advantage over any other method of propulsion.

UNDERWRITERS' LABORATORIES OPINIONS

In commenting upon the fire extinguishing efficiency of two-and-one half gallon chemical fire extinguishers of the soda-and-acid type, the Underwriters' Laboratories opine as follows:-





"Basing the discussion of the relative values of the soda-and-acid extinguishers and plain water and their respective extinguishing powers on fires of such a character that water and solutions containing water in large percentages are effective, when tried in a similar manner there would probably be little difference in the effect of the two streams. In all probability there would be some carbon dioxide carried over with the extinguisher stream and the heat of the fire may cause the evolution of a certain amount of carbon dioxide from the bicarbonate of soda, but the total results would probably be so small that the difference in the two liquids would be difficult to detect by means ordinarily at hand.

The value of the carbon dioxide gas produced by the chemical reaction in a soda-acid extinguisher is merely the provision of a source of power to expel the extinguishing fluid and is of very little practical value as an extinguisher. The extinguishing action results from cooling the burning mass by evaporation.

The chemical reaction in a soda-acid extinguisher produces sodium sulphate and carbon dioxide gas, and as the



sodium bicarbonate is used in much greater quantity than necessary for a complete chemical reaction, the result is that the stream of liquid issuing from the extinguisher consists of a solution of sodium bicarbonate and sodium sulphate mixed with a greater or less quantity of carbon dioxide, the latter being released from the stream more or less rapidly, depending on the temperature and other factors. The remaining portion of the gas evolved by the chemical reaction remains in the extinguisher until the liquid is entirely discharged, following this the gas is delivered in a stream which if properly directed against fires of a certain character will act as an extinguishing agent. The quantity of chemical products delivered and reaching the fire is negligible."

#### OPINIONS OF CHIEFS OF CITY FIRE DEPARTMENTS

A questionnaire was prepared and sent out to the chiefs of the Fire Departments of about fifty of the larger cities throughout the United States asking for their opinions as to the merits of and their experiences with chemical fire extinguishers. The questionnaire was



made up of the following questions:

Question 1- Do you consider the soda and acid stream from an extinguisher more effective than the same amount of plain water if applied in the same manner?

Question 2- Under what conditions is the chemical stream particularly valuable as distinguished from an equivalent stream of water?

Question 3- When part of a fire is put out by a soda-and-acid stream and the stream is then played on another part of the fire, have you noticed that the deposit, which has been made by the stream on the first part, has any appreciable effect in preventing that part from reigniting.

Question 4- Have you found many cases; such as partition and ceiling fires, fires back of bales and boxes, or in other confined places; where a chemical stream has put out fires, presumably by the gases formed, which could not be directly reached by a stream of water?

Question 5- Are there many incipient or small fires



of such nature to be handled?

Question 6 - Have you ever known any definite cases where the party, operating a chemical stream from either an extinguisher or engine, was injured by the stream coming in contact with electric wiring or machinery?

Question 7- Give any additional facts, opinions or information tending to show the superior effectiveness of soda-and-acid stream over plain water.

Of the total fifty-one replies received in answer to question No. 1, forty eight said yes, two said no, and one stated that he was unable to state

In answer to question 2, thirty one replied that a chemical stream was particularly valuable for inside fires and in enclosed places, four replies stated the stream to be valuable for oil and gasoline fires, ten for fires under all conditions, and three advised that the stream was no more than stream of plain water.

Thirty-seven answers to question No.3 said the deposit had an appreciable effect in preventing re-ignition, eight believed the deposit did not prevent re-igni-





nition, and one was unable to state.

In reply to question 4, thirty-four advised that they had found instances where the gas from a chemical stream had put out fires, while eight replied they had never found such a case, and three were unable to answer.

Replying to question No. 5, forty replies were received stating that there were many incipient or small fires to be handled, while two replied that there were not.

Forty two replies were received in answer to question No. 6 that no cases had been found of injury due to stream coming in contact with electric wiring or electric machinery, while five replied that such cases had been found.

The following are excerpts received in answer to question No. 7:

"Chemical stream, in my opinion is far superior to the same amount of water used in confined places."

"We use nothing but the A & S Extinguisher and tanks and they meet all requirements. On 4 years record 85% of fires in this Department extinguished



with chemicals."

"From the demonstrations for the Hazard Mfg. Co., in extinguishing fire of gasoline or ether, we had used the Pyrene Extinguisher to develop results in extinguishing the fire, we then tried soda and acid and got better results in extinguishing the same. It would prove disastrous to use water on gasoline fire!"

"I think, or in fact I know that the use of chemicals saves thousands of dollars for the Insurance Companies in this city. We extinguish between 70 and 80% of our fires with chemicals."

"In this City about 80% of our fires are put out with chemicals and it is a well known fact that you can go into a gouse with a chemical line and work there for an hour or more and as far as the water damage is concerned it would be very small bu use a water line for the same period of time and your water damage would amount to a great deal."

"Soda and Acid streams are fine and in most cases are sufficient for all incipient fires, and I have



used it effectively in many cases to hold big fires in check until additional help arrived."

"In my experiences I have found that Soda and Acid stream is much better inside of a building than the same amount of water."

"From our actual experience in handling fires we find that one gallon of carbonic acid gas and bicarbonate of soda is equal to ten gallon of water in putting out a confined fire. Have also noticed that the heat from a fire will dry water stream and ignite again, whereas with chemicals it is pretty hard for it to get started."

" The chemical stream is superior to water on all small fires inside of buildings with much less loss than if water were used."

"There is no comparison in fact we handle some good sized fires with chemicals. All of our Hose Wagons are equipped with chemical tanks. Our records show that we extinguish 85% of our fires with chemicals.

"Am a great admirer of the soda and acid stream. Do not consider the same amount of plain water would



be considered as effective by any fire fighter of any experience."

"We extinguish 95% of our fires that occur in residences with chemicals. We extinguish about 80% of our fires that occur in the city with chemicals. We are only too glad to be able to extinguish any fire with chemicals because it is far more satisfactory to the occupant, to the fireman, and keeps down the minimum the loss that is generally caused when using water to extinguish fires."

"Find it far superior in dwellings and dry goods stores with over 50% less damage than water."

"I consider the soda and acid extinguisher the most valuable for general use."

"In general, chief advantage is doubtless in quickness of operation and this would hold good even if there was no advantage in the chemical solution. In open air work the gas may be of less value than the deposit on the burning surface indoors and especially in confined spaces, the gas gets good action. For reliability as well as quickness of operation, ease and convenience of action, combined with quantity





enough to be serviceable. Nothing yet has any advantage over the  $2\frac{1}{2}$  gallon extinguisher."

"As stated before 60% of our fires are extinguished by chemicals and I figure them one of the essentials of the Department."

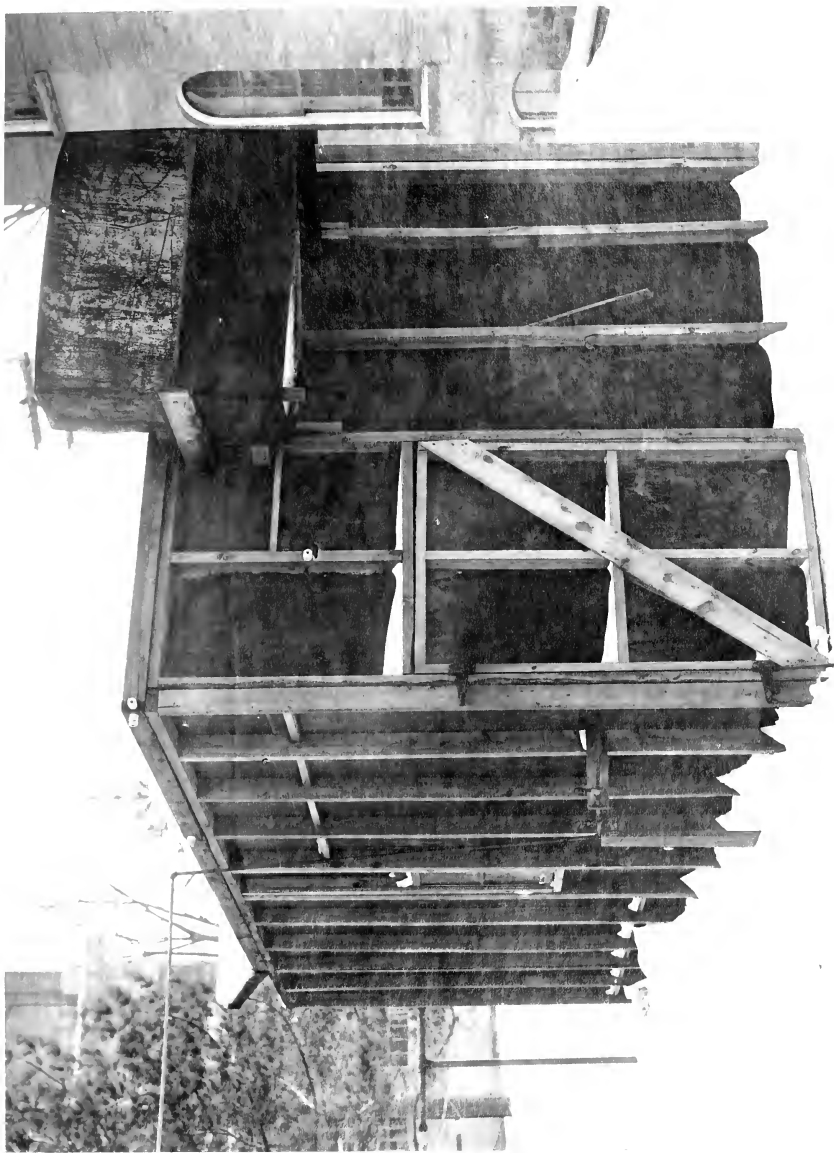
#### DESCRIPTION OF TEST APPARATUS

The test house in which the tests were conducted was made of 2" x 4" yellow pine framing, lined inside with 22 gauge sheet iron. A swing hatch the full width of the building was provided at the rear end. All fires were made under this hatch.

A baffle 11 ft. 6" long, and full width of the building was used to deflect the smoke towards the front of the building, when the rear hatch was closed. The smoke deflected by this baffle escaped through a small door at the front of the test house. Connections were made at the front of the building for attaching gauges, extinguishers, etc. The attached drawings and photographs show the test house in detail.

The soda and acid extinguisher used was a

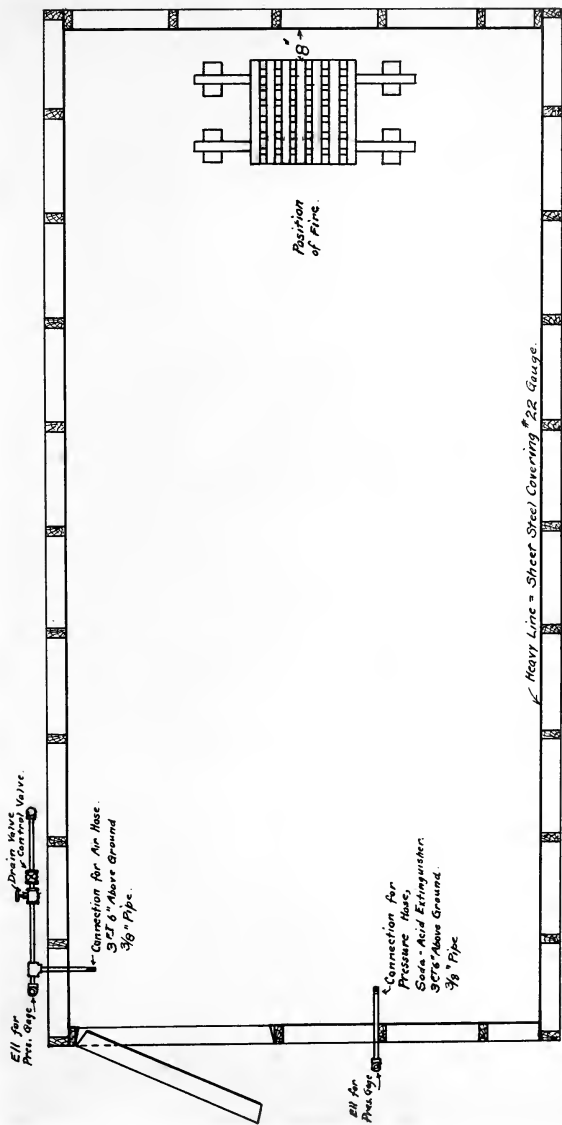












FLOOR PLAN.





regular  $2\frac{1}{2}$  gallon approved extinguisher made by the O.J. Childs Company of Utica, N.Y. The water extinguisher used consisted of a  $2\frac{1}{2}$  gallon Childs extinguisher without the acid bottle and cage. The device was fitted with a  $1/3$ " pipe screwed through the cap and extending down to within one-half inch of the bottom of the tank. The opposite end of the pipe was connected by means of flexible tubing and iron pipe to a source of air supply.

Bleeder and control valves together with a pressure gauge were provided in the air line to regulate the air pressure to that desired. A standard one-eighth inch nozzle was used for both the water and the soda extinguisher, the same nozzle being used for all tests.

#### GENERAL TEST PROCEDURE

The soda and acid extinguishers were prepared as follows: Two gallons of water were poured into a galvanized pail and  $1-1/3$  lbs. of soda added. The solution was thoroughly mixed. Sufficient water was then added to bring the total volume to two



and one half gallons. The solution was then poured into the extinguisher, and the level noted.

The sulphuric acid used for all tests was from the same batch, the density being 66° Baume at 60° Fahr. Four fluid ounces of acid were measured, and poured into the acid bottle, the same stopple being used for all tests. Just before being used, the solution in the extinguisher was brought to 70° Fahr. by placing the extinguisher in cans of hot or cold water.

Just before being used the water in the water extinguisher was also brought to 70° F by placing the extinguisher in either hot or cold water.

For all water tests, the pressure on the water extinguisher were so regulated that the time required for the two and one half gallons of water to be expelled was the same as the time required for the two and one half gallons of solution to be expelled from the soda and acid extinguisher. A series of tests were run in order to determine the necessary range of pressures to be used on the water extinguishers. These pressures are tabulated on the data sheets for the water tests. All pressures were measured with



a standard calibrated test gauge.

It was found that with the same pressure ranges the water extinguisher would discharge in a much shorter time than the soda acid extinguisher. This was due to the fact that the stream from the water machine was solid, whereas the stream from the soda acid machine was more or less impregnated with gas.

The pressures used on the water extinguishers were necessarily much lower than those generated in the soda acid extinguisher. Under these pressures, the stream from the water extinguisher was much weaker than that from the soda acid extinguisher, operating under normal conditions. This condition was particularly noticeable during the first fifteen seconds of operation, but was nevertheless true for the entire time of discharge.

As far as possible, the tests were run in pairs, a soda acid test, and then a water test on the same type and size of fire. This procedure was followed in order to avoid any change of atmospheric conditions.

Wood from the same batch was used for each pair



of fires, in order to eliminate errors due to difference in quality. Approximately the same weight of wood was used for each fire of a pair. The actual weights are given on the log sheets.

The sample consisted of a number of tiers of 3" x 2" x 2' yellow pine pieces supported on angle irons. The sample was placed at the rear of the test house, under the roof hatch. The distance from the back of the sample to the rear wall of the test house was 8" in all cases. The sample was centrally located with regard to the side walls. The bottom of the sample was placed 16 inches above the floor of the test house. A sheet metal pan containing one-half gallon of gasoline was placed so that the bottom of the pan was 13 inches below the bottom of the sample. The methods of conducting the tests were as follows: The roof hatch in rear of building was opened to a definite position as shown on the drawings. The small door at the front of buildings was closed. The main door was wide open. The windows in the side of the building were closed. The gasoline was ignited, and<sub>31</sub> observations at one minute





intervals were taken as shown on the log sheets. At the end of the tenth minute, the roof hatch was closed, the small door opened, and the main door closed to four inches. The extinguisher was then applied, observations of pressures and the condition of the fire taken every five seconds. After the extinguisher had been exhausted, the sample was examined, and its contents recorded. The main door and the roof hatch were then opened, and the samples watched for several minutes in order to give it opportunity to rekindle. The pile was then torn apart and the different tiers examined to determine their condition. The extinguisher operator used a smoke helmet. The same operator was used for all tests.

The method of fighting the fire was standardized as far as possible. The operator started to fight at fifteen feet. At the end of five seconds he had moved up to ten feet, if the heat was not too intense to prevent it. At the end of ten seconds he was usually fighting at five feet, and for the remainder of the time he was fighting up close. The extinguisher was



applied first at the bottom of the sample, and as the fire was extinguished, the stream was moved toward the top of the sample. As soon as the operator moved up close to the fire, he applied the extinguisher to the two sides and to the front of the sample, but not to the back.

A number of tests were made with freely burning wood fires. A series of preliminary tests were made in order to determine the limit of the soda acid extinguisher. The weight of wood used was increased until the fire taxed the soda acid machine to its limit. A water test was also made with each size of fire. After the limit of the soda acid extinguisher had been found, a number of comparative tests, were made with the same size fires. A sufficient number of tests were made to eliminate personal error of the operators and observers.

#### FIRE TESTS

Soda Acid Test No.1 Aug. 5, 1919.

Freely Burning Wood Fire

Material used: 56 pieces yellow pine 2" x 2" x 2';  
1/2 gal. gasoline 58° Baume.



Weight of wood 119 lbs.

Wood was arranged in eight tiers seven pieces to a tier. Temp. of test house 68° F. Weather conditions, cloudy, no wind. Extinguisher temp. 70° Fahr.

Time

- 0 Gasoline ignited
- 1 min. Gasoline flames enveloping sample.  
Tongues of flames from all sides.  
7 ft. high. Slight draft from left.  
Flames surge back and forth
- 2 min. First three tiers afire. Flames  
envelopesample, 15 ft. high, flames  
straight up.
- 3 min. All but three upper tiers afire,  
flames 15ft. high. Tongues extend  
3" from all sides. Flames straight  
up.
- 4 min. Sample burning evenly throughout,  
flames 12 ft. high, straight up,  
Tongues 4" from all sides. Few  
embers begin to fall. Gasoline out  
at 4 min. 10 sec.



Extinguisher Time  
Press.

	5 min.	Embers falling, flames 15ft. high sample burning freely.
	6 min.	Heat intense, flames 3" from all sides. Two lower tiers show many glowing embers.
	7 min.	Same as before.
	8 min.	Embers on three lower tiers, slight crackling, flames 13 ft. high.
	9 min.	Flames straight up, many embers falling. Four lower tiers aglow with embers.
2	10 min.	Operator applied soda acid ex- tinguisher.
55	10 min.5sec.	Flames extinguished in lower half of sample, fire apparently under control. Fighting at 16 ft.
80	10 min.10sec.	Fire under control, flames 3ft. high at right back corner of sample.
102	10 min.15sec.	No flames visible, operator close up working on front and sides of sample.





Extinguisher  
Press.

Time

106                    10 min.20 sec.    No flames visible, operator  
close up, working on front  
and sides of sample.

97                    10 min.25 sec.    Same.

85                    10 min.30 sec.    Same.

74                    10 min.35 sec.    Same.

67                    10 min.40 sec.    Same.

60                    10 min. 45sec.    Same.

56                    10 min.50 sec.    Same.

Gas                    10 Min. 53sec.    Gas at extinguisher

52                    10 min. 55 sec.    Applying gas to sample.

33                    10 min. 60 sec.    Main door and hatch opened

22                    10 min. 65 sec.

12 min. 65 sec.    Few embersat back of lower  
tier.

14 min.              No embers visible.

The four lower tiers were charred practically  
thruout, other tiers being charred  $\frac{1}{4}$  to  $\frac{1}{2}$  their thick-  
ness.

One-half pint of solution remained in  
extinguisher.







Freely Burning Wood.

Material used: 56 pieces yellow pine 2" x 2" x 2ft.,  
1/2 gal. gasoline 58° Baume.

Weight of wood 117-5 lbs.

Wood was arranged in eight tiers, seven pieces to a tier.  
Temp. of test house 71° F. Weather conditions cloudy, no  
wind. Extinguisher temp. 70.5° Fahr.

Time

- |        |  |
|--------|--|
| 0      | Gasoline ignited   |
| 1 min. | Flames concentrated at right back<br>corner. First two tiers afire,<br>flames 15ft. high.                        |
| 2 min. | Flames enveloping back and sides of<br>sample. 12 ft. high. First five<br>tiers afire, few embers on lower tier. |
| 3 min. | Flames 15 ft. high, all tiers afire,<br>flames 1 ft. from right of sample,<br>6" from other sides.               |
| 4 min. | Flames 13 ft. high, sample burning<br>evenly, all tiers afire. Right   |



Extinguisher  
Press                      Time

side shows embers in lower five tiers. Crackling sound. Gasoline out.

5 min.                      Embers show on all tiers, sample burning evenly, flames 12 ft. high. Few embers falling.

6 min.                      Flames 12ft. high, all tiers show embers, heat intense, flames extend 4 in. from all sides.

7 min.                      Same as before, sample burning freely.

8 min.                      Embers falling freely, all tiers show embers.

9 min.                      Falling embers increasing, burning strongly. Heat intense, operator unable to approach fire closer than 10'

0                      10min.                      Extinguisher was applied.

15                      10 min.5sec.Flames extinguished in lower tier, flames 10 ft. high.

33                      10 min.10sec.Operator moves to 5ft. flames 6' high, fire not under control.





Extinguisher Press	Time	
47	10 min. 15 sec.	Fire under control, flames 6' high, fire out in lower two thirds of sample.
55	10 min. 20 sec.	Few flames visible at back of sample.
60	10 min. 25 sec.	No flames visible.
62	10 min. 30 sec.	Fire apparently out.
58	10 min. 35 sec.	
52	10 min. 40 sec.	
43	10 min. 45 sec.	Sample smoking
37	10 min. 50 sec.	Operator still apply- ing Extinguisher.
Air	10 min. 51 sec.	Air at extinguisher Nozzle.
32	10 min. 55 sec.	Few embers visible.
	11 min. 15 sec.	Embers show practically all tiers at back of sample, also at center of pile.



Extinguisher  
Press

Time

11 min. 30 sec.	Embers at back and front of lower tier. Sample smoking.
14 min.	Rear hatch opened.
16 min.	Embers did not rekindle.

Sample was well charred thruout, lower four tiers almost burned up.

One fourth pint of water remained in the extinguisher.

Soda Acid Test No.2

Aug. 5, 1919.

Freely Burning Wood Fire.

Material used: 56 pieces of yellow pine 2" x 3 ft.  $\frac{1}{2}$  gal.  
of gasoline 58° Baume.

Weight of wood 116 lbs.

Wood arranged in eight tiers, seven pieces to a tier. Temp of test house 73° Fahr.

Temp. of solution 70° Fahr. Weather conditions, cloudy, no wind.

Time

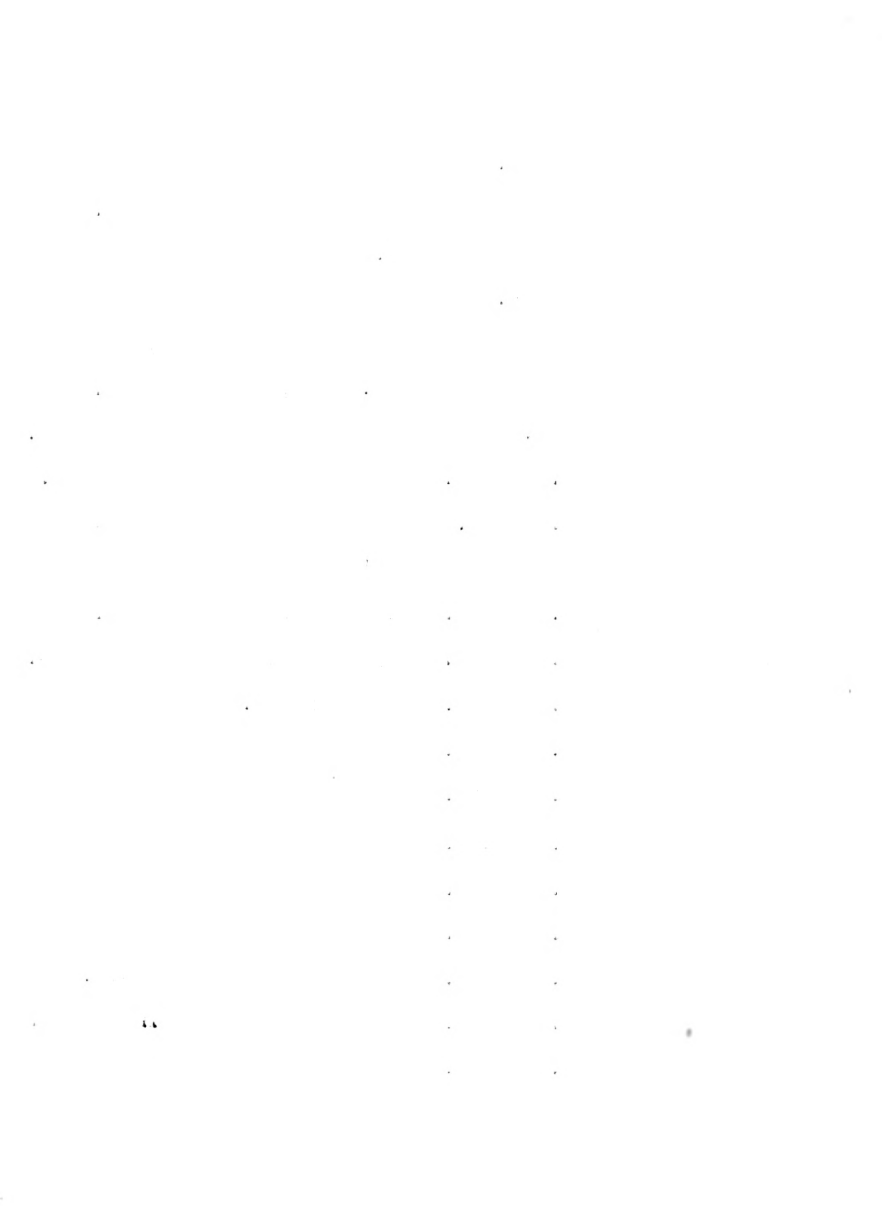
0 Gasoline ignited.



Time	
1 min.	Flames enveloping sample, flames 12 ft. high, and extending 3 in. from all sides, heavy smoke, much crackling.
2 min.	Flames off to right. All tiers afire except two top ones, flames 12 ft. high.
3 min.	Sample burning evenly, evenly, all tiers afire, no side draft.
4 min	Tongues of flame 4in. from all sides. Gasoline burned out. Two lower tiers beginning to char.
5 min.	Draft straight up, flames 10 ft. high.
6 min.	Flames 15 ft. high, lower tiers well charred.
7 min.	Same as for 6 min.



Extinguisher	Time	
Press	8 min.	Embers show thruout sample, few falling, flames 15 ft. high.
	9 min.	Embers falling, and being carried up with draft, flames 15 ft. high, heat intense.
0	10 min.	Soda acid extinguisher applied.
35	10 min. 5 sec.	Flames out in lower half pile.
34	10 min. 10 sec.	Fire under control, fighting at 10'
90	10 min. 15 sec.	Fire out, fighting at 5ft.
101	10 min. 20 sec.	Applying extinguisher close up.
100	10 min. 25 sec.	Sample smoking.
86	10 min. 30 sec.	
73	10 min. 35 sec.	
67	10 min. 40 sec.	
61	10 min. 45 sec.	
56	10 min. 50 sec.	
Gas	10 min. 51 sec.	Gas at extinguisher nozzle.
40	10 min. 55 sec.	Operator applying extinguisher.
25	10 min. 60 sec.	" " "





Extinguisher  
Press

Time .

15	10 min. 65 sec.	Operator applying extinguisher
	10 min. 70 sec.	Operator applying extinguisher
	13 min.	Door and hatch opened.  Few glowing embers visible at back right corner, and in tier next to the top. Many small glowing embers show thruout sample. They are apparently going out. Sample is well charred thruout.
	14 min.	Embers are practically out.



Water Test No. 2

Aug. 5, 1919.

Freely Burning Wood Fire

Material used: 56 pieces yellow pine 2" x 2" x 2',  
1/2 gal. gasoline 55° Baume.

Weight of wood 115 lbs.

Wood arranged in eight tiers, seven pieces to a tier.

Temp. of test house 75° Fahr.

Weather conditions cloudy, no wind.

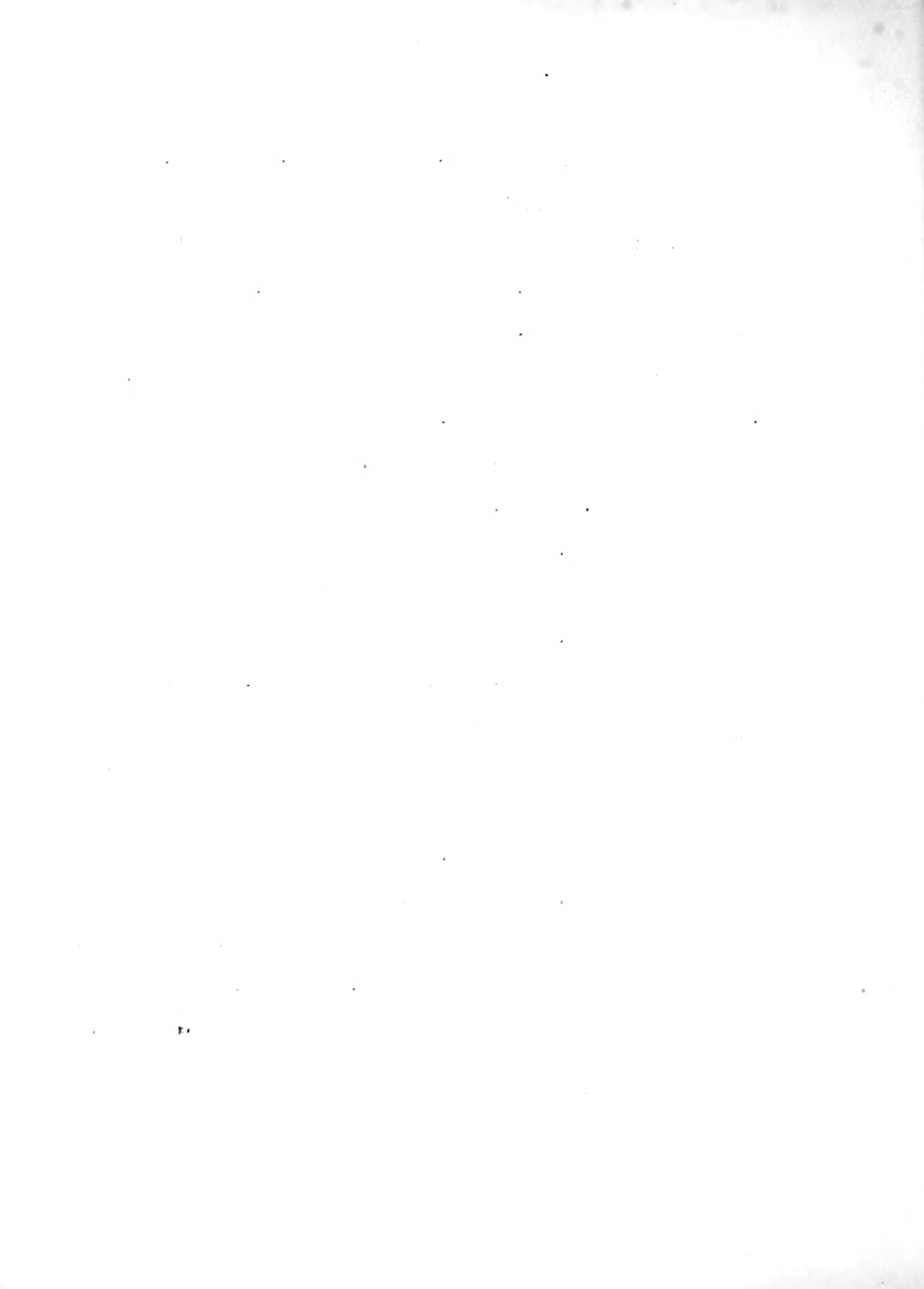
Extinguisher temp. 70° F.

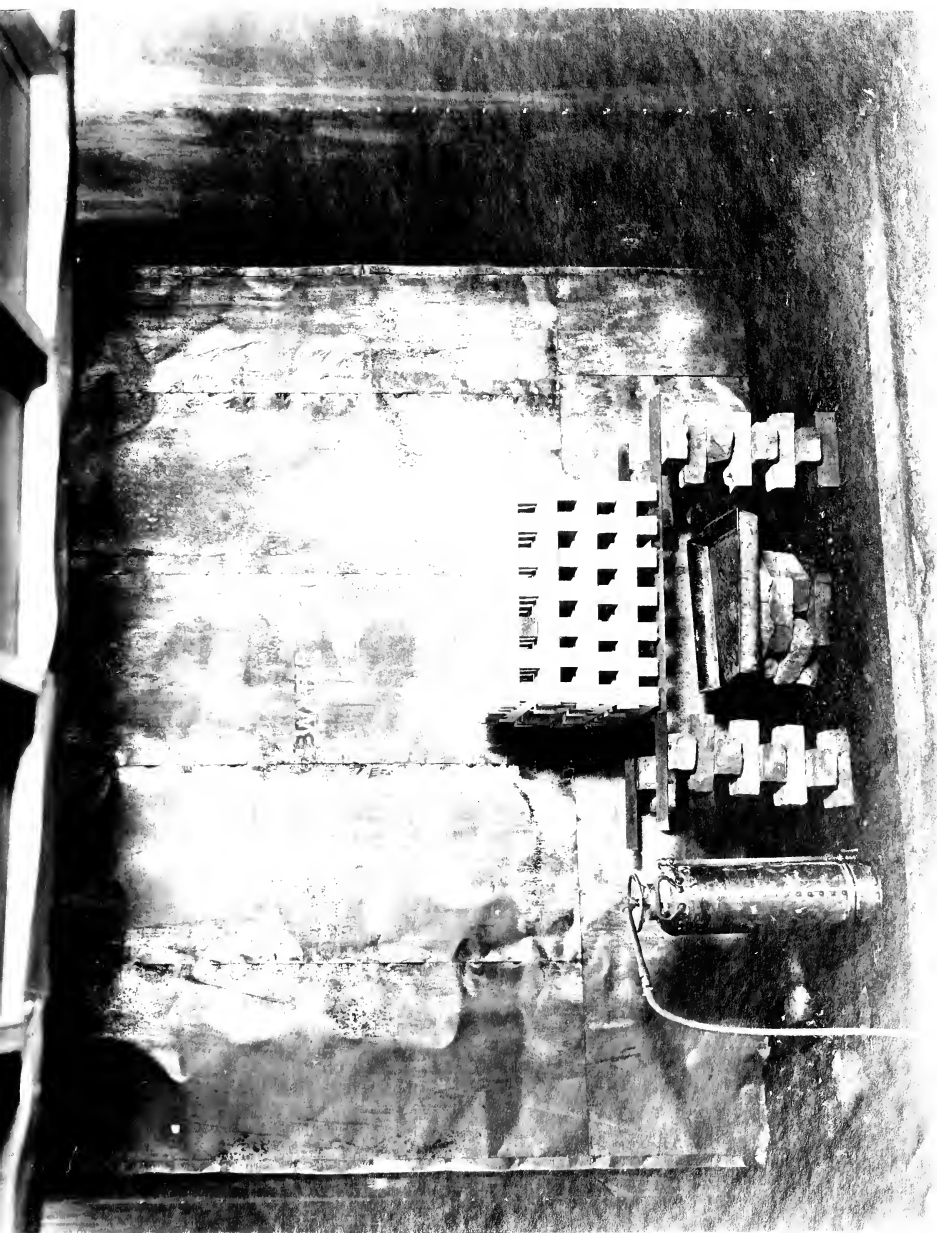
Time.

0 Gasoline ignited

1 min. Flames concentrated at back of  
sample, flames 10 ft. high,  
first two tiers afire, tongues  
of flame from right side of sam-  
ple, slight evidence of side  
draft.

2 min. Gasoline, burning, flames envelop-  
ing sample first four tiers afire,  
flames 12 ft. high, concentrated  
at right side, slight side draft.







Time

- 3 min. Tongues of flames 8 in. from right of sample, 3 to 4 inches from other sides, flames 15 ft. high. First four tiers afire.
- 4 min. Sample burning evenly thruout, all tiers afire embers show on three lower tiers, flames 3 to 4 inches from sides, flames 12 ft. high. No evidence of side draft. Gasoline out.
- 5 min. Flames 12 ft. high, embers on all tiers, sample burning uniformly, no evidence of side draft.
- 6 min. Flames straight up, about 12ft. high. Embers show on all tiers, none falling, heat intense.
- 7 min. All tiers afire, flames 12 ft. high.
- 8 min. Glowing embers thruout sample, all tiers show decrease in size.





Extinguisher  
Press

Time

	9 min.	Embers falling freely, heat intense, flames 12 ft. high.
0	10 min.	Extinguisher was applied
15	10 min. 5 sec.	Two lower tiers show no flames.
35	10 min. 10 sec.	Flames 10 ft. high, fire out in lower third pile.
47	10 min. 15 sec.	Fire under control, flames three ft. above sample.
55	10 min. 20 sec.	Flames 1 ft. above sample at back right corner.
60	10 min. 25 sec.	All flames extinguished.
62	10 min. 30 sec.	All flames extinguished, few embers visible.
58	10 min. 35 sec.	Few embers visible at back of sample.
52	10 min. 40 sec.	
43	10 min. 45 sec.	
37	10 min. 50 sec.	Heavy white smoke, no obser- vations possible.



Extinguisher  
Press

Time

Air	10 min. 52 sec.	Air at nozzle
	10 min. 30 sec.	Hatch and doors opened
	12 min.	Sample smoking few embers visible in lower tier.
	13 min.	Embers dying out.
	14 min.	No embers visible, fire completely out

The front of sample, and back left corner was not fully charred. The lower tiers were charred to about one half their thickness, the remaining tiers about one third their thickness.

One tenth pint of water remained in the extinguisher.

Soda Acid Test No. 3 Aug. 6, 1919.

Freely Burning Wood Fire.

Material used: 84 pieces yellow pine 2" x 2" x 2', 1/2 gal. gasoline 58° Baume.

Weight of wood 132 lbs.

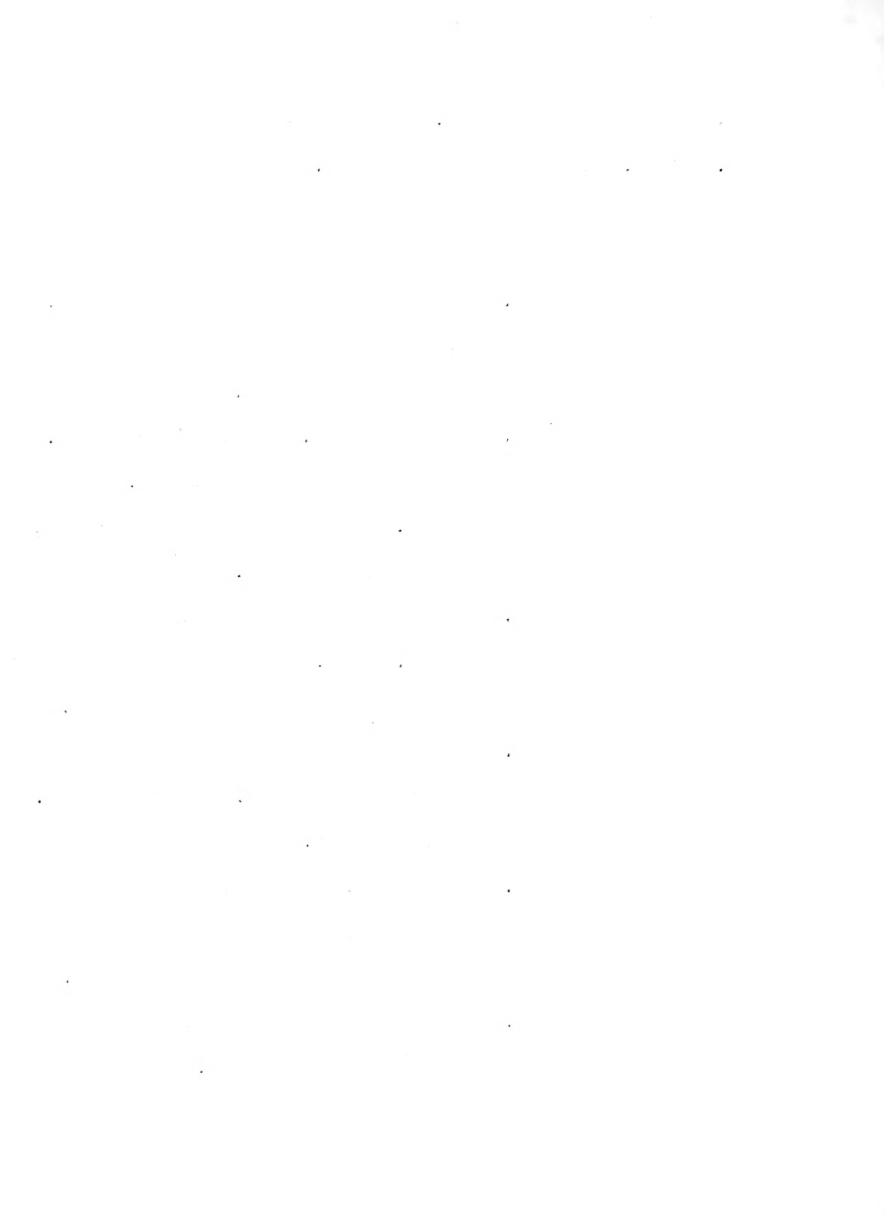
Wood arranged in twelve tiers, seven pieces to a tier.



Temp. of test house 75° F. Weather clear, slight wind. Temp. of extinguisher 70° F.

Time

- 0 Gasoline ignited
- 1 min. Flames enveloping sample, 12 ft. high, heavy black smoke, two lower tiers afire.
- 2 min. Flames 15 ft. high, flames 1 ft. from sides of sample, 3 in. from front. Four lower tiers burning, slight side draft.
- 3 min. Six lower tiers afire, flames about 13 ft. high. Wood burning strongly flames 3" from sides of sample.
- 4 min. All tiers afire, embers show on three lower tiers. Heat intense. Gasoline cut.
- 5 min. Few embers falling, crackling sound flames straight up, embers show on four lower tiers, heat intense.
- 6 min. All tiers show embers, no embers on right side of sample. Flames straight



Extinguisher  
Press

Time

up 13 ft. high. Tongues  
of flames 4 in. from all  
sides

7 min. Embers falling and going up  
with draft. Embers show on  
all tiers. Flames straight  
up 19 ft.

8 min. Embers falling freely, all  
tiers aglow.

9 min. Every piece ablaze and aglow  
with embers, flames about 20  
ft. high, test house burning  
on top and at back. Many  
embers falling and going up  
with draft.

0 10 min. Soda acid extinguisher app-  
lied, after hatch and main door  
were shut, and damper opened,  
started fighting at 15 ft.

40 10 min. 5 sec. Flames extinguished in lower  
49 third of pile.





Extinguisher Press	Time	
75	10 min. 10 sec.	Flames extinguished in lower half but many embers still visible, flames 3 ft. high.
97	10 min. 15 sec.	All flames extinguished except at back right corner. Fire well under control.
101	10 min. 20 sec.	All flames out, few embers visible.
98	10 min. 25 sec.	Few embers visible, heavy white smoke.
90	10 min. 30 sec.	Few embers still visible.
80	10 min. 35 sec.	Same, operator applying extinguisher from sides and front.
70	10 min. 40 sec.	Same
64	10 min. 45 sec.	Embers visible lower tier.
60	10 min. 50 sec.	Same as before.
Gas	10 Min. 52 sec.	Gas at extinguisher.



Extinguisher Press	Time	
50	10 min. 55 sec.	Operator applies gas to sample.
35	11 min.	Fire apparently cut, gas used up, main door and hatch opened.
	12 min.	Small ember visible back center of lower tier.
	14 min.	Embers still glowing, not increasing in size.
	15 min.	Embers going out, did not rekindle.

The sample was well charred thruout, the lower tiers being practically consumed.

One pint of liquid remained in the extinguisher.

Water Test No. 3      Aug. 3, 1919.

Freely Burning Wood Fire

Material used: 84 pieces yellow pine 2" x 2" x 2',

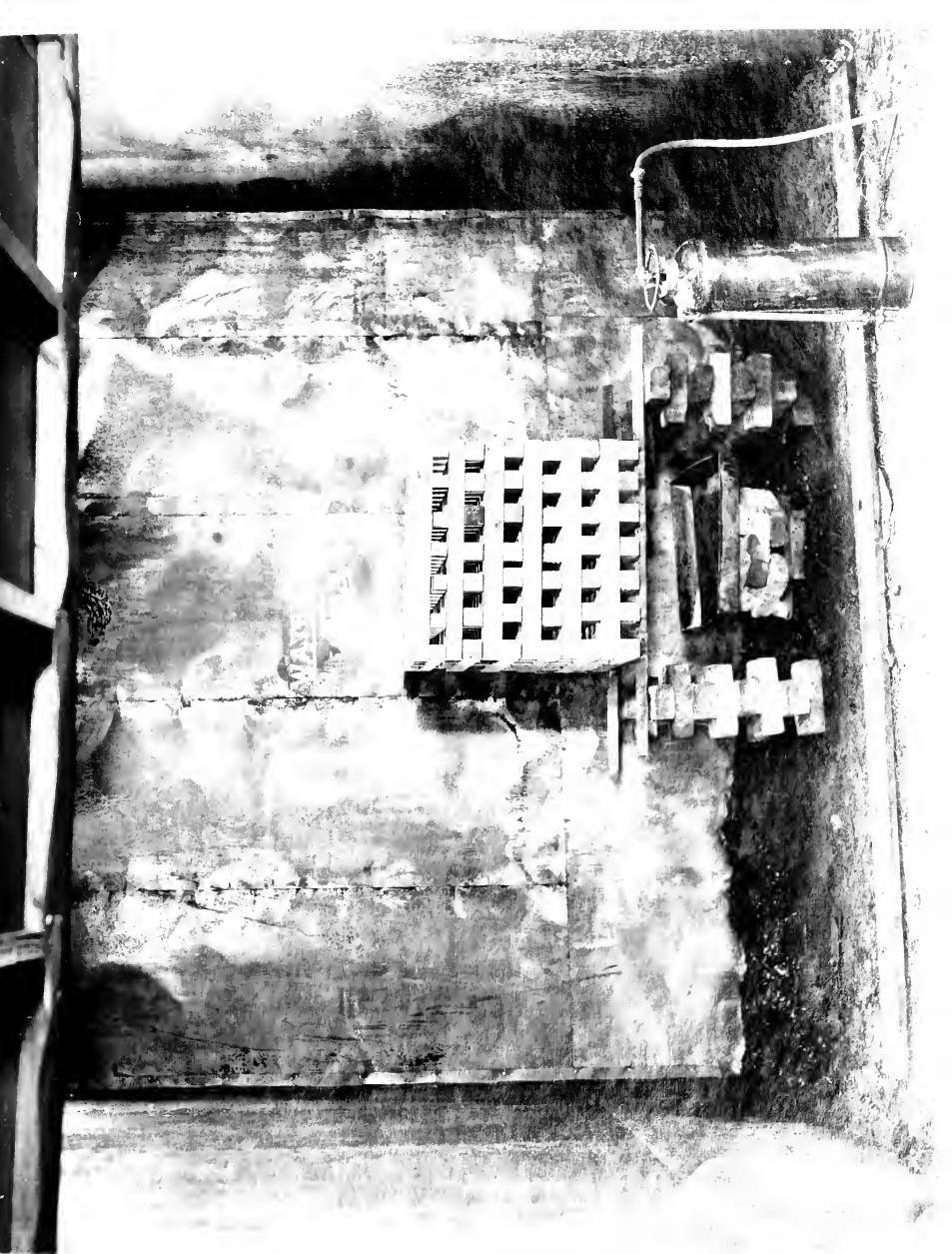
1/2 gallon gasoline 58° Baume.

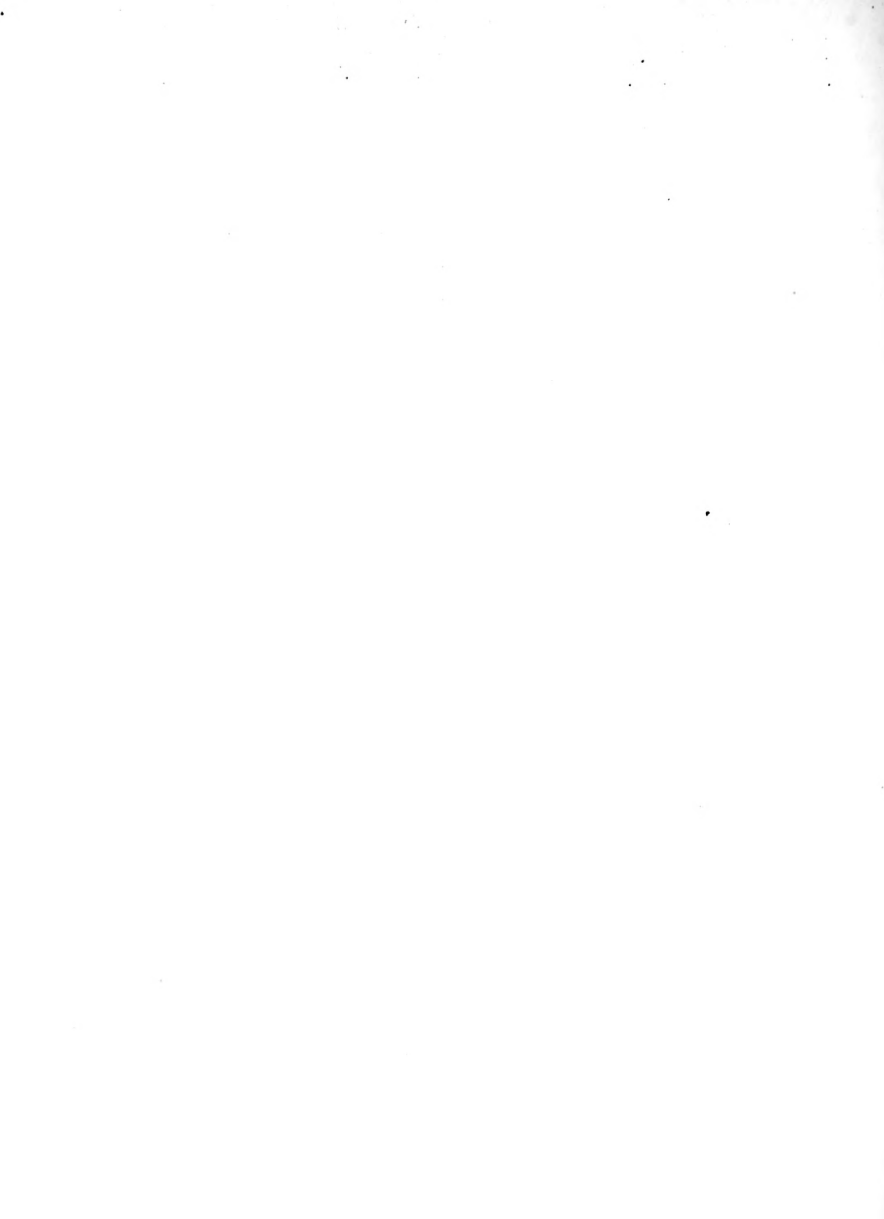
Weight of wood 131 lbs.

Wood arranged in tiers, seven pieces to a tier. Temp. of

1170041

512





test house 79° Fahr. Temp. of water 70° Fahr.

Weather clear, slight wind.

Time	
0	Gasoline ignited
1 min.	Flames 12 ft. high, surging to right. Four lower tiers afire.
2 min.	Evidence of side draft, flames off to right. Flames 12 ft. high, 4 in. from all sides.
3 min.	First six tiers afire, flames enveloping sides and back of sample, 12 ft. high.
4 min.	Gasoline out, sample burning evenly, flames straight up 12 ft. high. Four lower tiers show embers.
5 min.	All tiers afire, sample burning strongly, flames 13 ft. high.
6 min.	All tiers show embers, flames 12 ft. high, sample burning stronger at back right corner.
7 min.	Flames 15 ft. high, heat intense, much crackling.





Extinguisher Press	Time	
	8 min.	Embers thruout sample some falling. Flames 12 ft.high. Top tiers shows, has burned about halfway.
	9 min.	Flames 15 ft. high, all tiers show embers many falling,heat intense.
0	10 min.	Hatch and main door closed damper opened, water extin- guisher applied.
15	10 min. 45 sec.	Flames extinguished in two lower tiers, fighting at 10 ft. flames 10 ft high.
33	10 min. 10 sec.	Lower third of fire out flame 3 ft. high.
47	10 min. 15 sec.	Fire under control, fight- ing close up, flames 3 ft. high at back of sample.
55	10 min. 20 sec.	Flames 1 ft. above sample



Extinguisher Press	Time	
60	10 min. 25 sec.	No flames visible, no embers visible, heavy white smoke.
62	10 min. 30 sec.	Few embers falling, no flames visible.
58	10 min. 35 sec.	Force of steam causes embers to fall, no flames.
52	10 min. 40 sec.	No. embers visible, white smoke.
43	10 min. 45 sec.	Same.
37 air	10 min. 50 sec.	Air at extinhuisher nozzle.
18	11 min.	Hatch and main door opened. Embers at front and back of lower tier, also small embers scattered thruout pile.
	12 min.	Sample smoking strongly.
	14 min.	Embers did not rekindle, are apparently going out.



The pile was well charred thruout all tiers being deeply burned, top and bottom tiers almost consumed.

One eighth pint of water remained in the extinguisher.

Soda Acid Test No. 4 Aug. 12, 1919.

Freely Burning Wood Fire

Material used: 77 pieces yellow pine 2" x 2" x 2 ft.

1/2 gal. gasoline 58° Baume.

Weight of wood 143 lbs.

Wood arranged in eleven tiers, seven pieces to a tier

Temp. of extinguisher solution 70° Fahr.

Weather clear, no wind. Temp. of test house 76° Fahr.

Time

0	Gasoline ignited.
1 min.	Flames concentrated at back of sample, 10' high, no side draft
2 min.	First six tiers afire, flames 12 high. Draft towards right. Tongues of flames 1' from right side, 3" from other sides.
3 min.	First seven tiers afire, slight



Time

- draft to right, flames 12' high. Embers show on right side of sample and on lower tier, flames extend 3" from all sides.
- 4 min. All tiers afire, sample burning strongly, embers on first six tiers. Gasoline out. Flames straight up, 12' high. Embers falling much crackling.
- 5 min. All tiers show embers. Embers falling freely, flames straight up, 13 ft. high.
- 6 min. Flames 14 ft. high. Large embers falling. Sample burning evenly.
- 7 min. Many embers falling, flames 14' high.
- 8 min. Four lower tiers almost burned away. Flames 15 ft. high. Many embers falling.
- 9 Heat intense, condition of fire same as for 8 min.





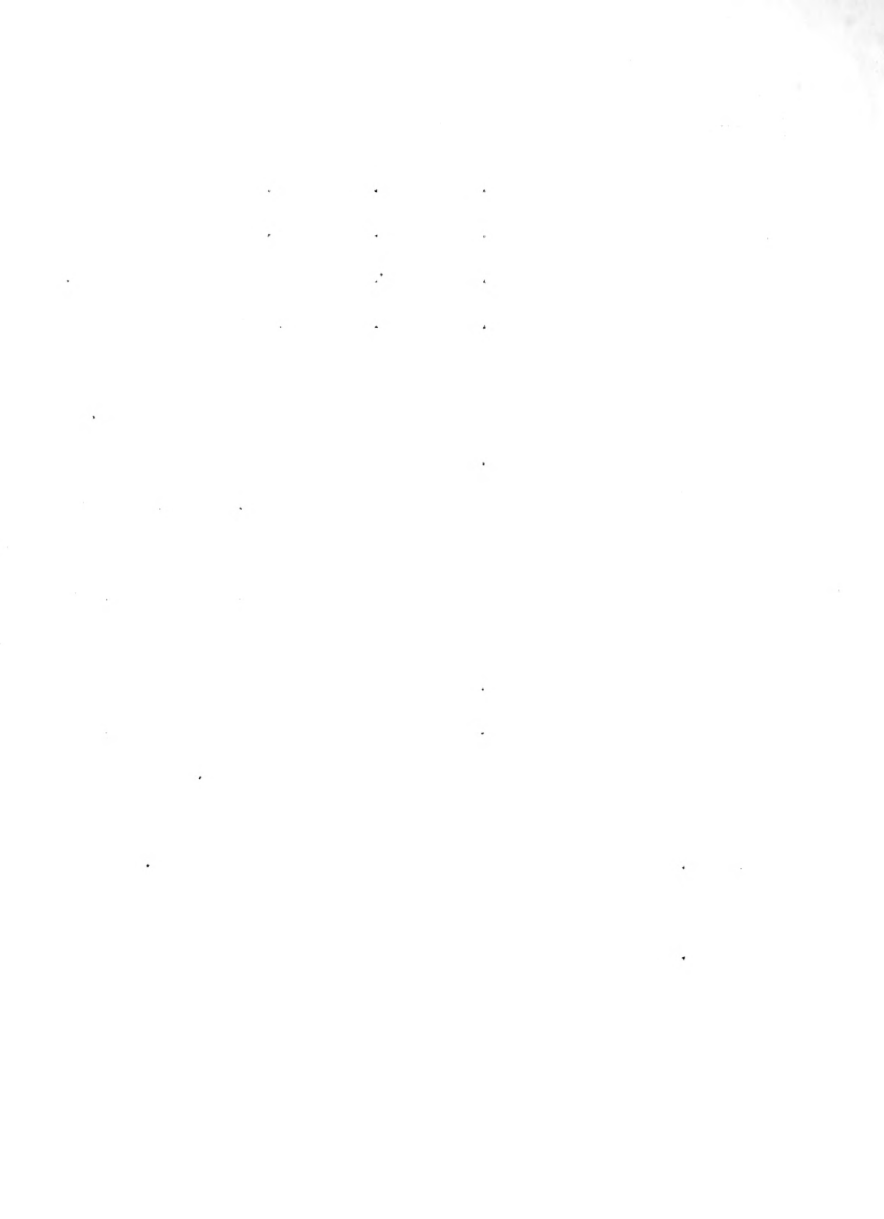
Extinguisher Press.	Time	
0	10 min.	Hatch and main door closed damper opened, soda acid extinguisher applied.
35	10 min. 5 sec.	Flames 10 ft. high, out in three lower tiers.
75	10 min. 10 sec.	Flames out in lower half of sample, 4 ft. high
93	10 min. 15 sec.	Fighting at 5 ft. Flames 2' high at back left corner, fire well under control.
103	10 min. 20 sec.	Few flames visible at back of sample.
97	10 min. 25 sec.	All flames out, few embers visible.
83	10 min. 30 sec.	No. embers visible, white smoke.
76	10 min. 35 sec.	Operator applies extinguish- er close up, no embers visible.
67	10 min. 40 sec.	Same



Extinguisher Press	Time	
61	10 min. 45 sec.	Same.
57	10 min. 50 sec.	Same.
43	10 min. 51 sec.	Gas at extinguisher.
35	10 min. 55 sec.	Operator applies extinguisher until gas is exhausted .
	11 min.	Hatch and main door opened. Patch of embers 6" square at right back corner, smoking strongly, also small patch at front
	13 min.	Embers decreasing in size
	15 min.	Did not rekindle, embers going out.

The sample was charred thruout except the extreme corners. The lower tiers were entirely charred.

One eighth pint of solution remained in the extinguisher.



Water Test No. 4.

Aug. 12, 1919.

Freely Burning Wood Fire.

Material used: 77 pieces yellow pine 2" x 2" x 2',  
1/2 gal. gasoline 58° Baume.

Weight of wood 144 lbs.

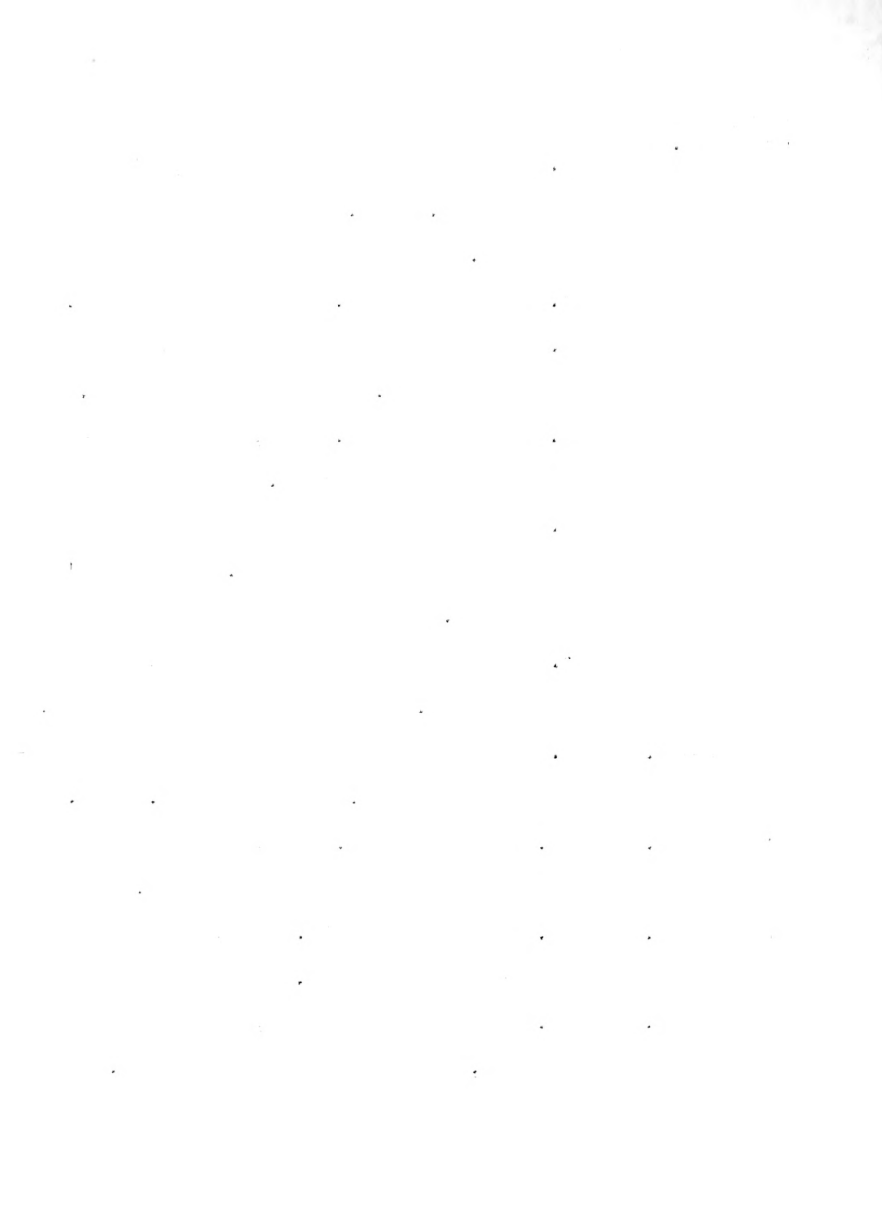
Wood arranged in eleven tiers, seven pieces to a  
tier. Weather clear, no wind. Temp. of test house  
78° F. Temp. of Extinguisher 70° F.

Time

- 0 Gasoline ignited.
- 1 min. First four tiers afire, flames  
10 ft. high, draft to right.
- 2 min. All except two upper tiers  
afire. Flames encircling  
right and back, 12 ft. high,  
much crackling.
- 3 min. All tiers afire, embers showing  
on three lower tiers, flames 13ft.  
high, draft straight up.
- 4 min. Flames 14 ft. high, embers on four  
lower tiers. Draft straight up.  
Gasoline almost out. Embers fall-  
ing freely.

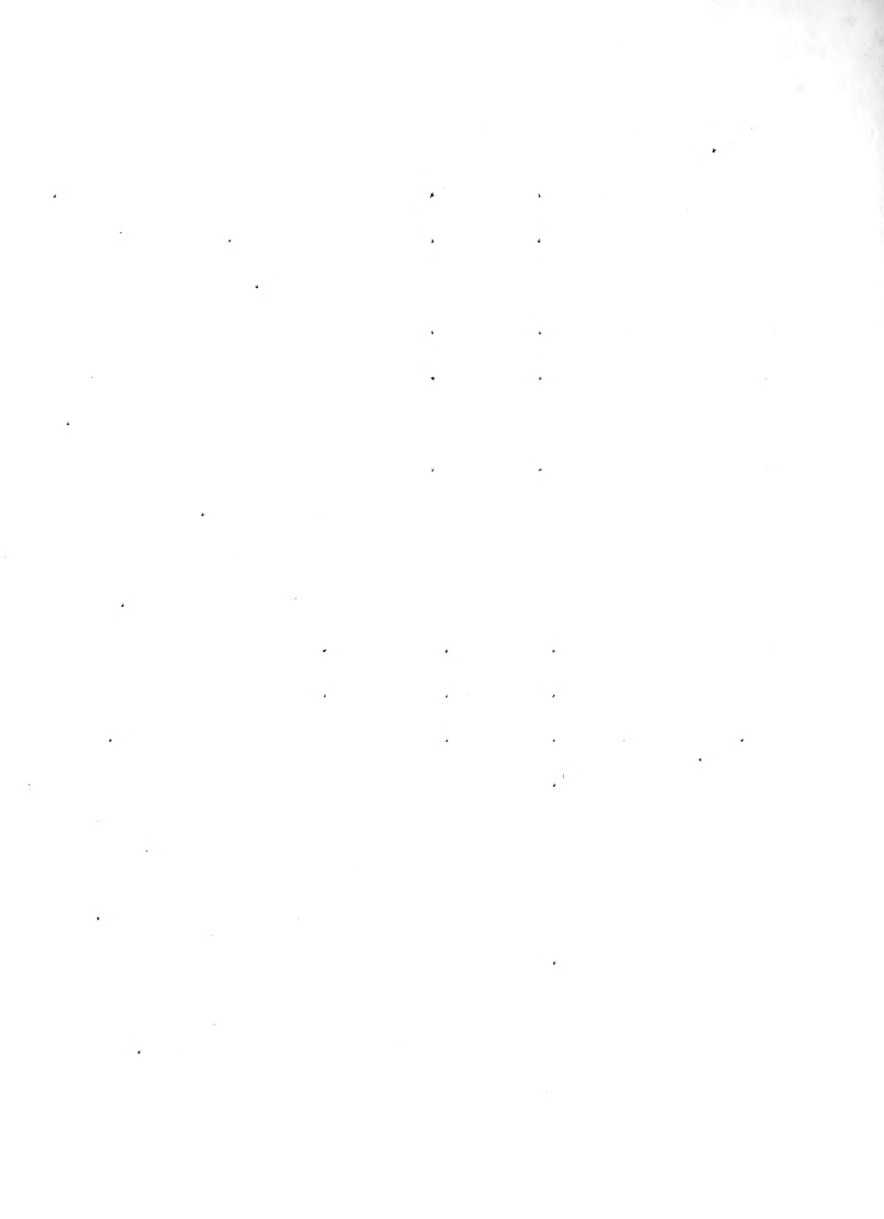


Extinguish- er Press.	Time	
	5 min.	Embers show on all tiers, flames 15 ft. high. Embers falling freely.
	6 min.	Flames 16 ft. high, heat intense.
	7 min.	Large embers on all tiers, violent crackling. Many embers falling.
	8 min.	Flames 13 ft. high, sample burning very strongly.
	9 min.	Heat intense, sample aglow with embers, many falling. Flames 14' high.
0	10 min.	Main door and hatch closed, damper opened. Water extinguisher applied
15	10 min. 5 sec.	Flames out in two lower tiers, fighting at 10 ft. Flames 12 ft. high.
33	10 min. 10 sec.	Flames 10 ft. high, flames extinguished in lower third of sample.
47	10 min. 15 sec.	Flames three ft. high, burning at center and back.
55	10 min. 20 sec.	Fire under control, fighting close up, burning at center of pile.





Extinguisher Press,	Time	
60	10 min. 25 sec.	Burning strong at center.
62	10 min. 30 sec.	Flames 1 ft. high at back of sample.
58	10 min. 35 sec.	Small flames at back center
52	10 min. 40 sec.	No flames visible, embers at center of lower tier.
43	10 min. 45 sec.	Embers smoking strongly but no flames.
		Operator applying extinguish- er from three sides.
37	10 min. 50 sec.	Same.
32	10 min. 55 sec.	Same.
Air.	10 min. 57 sec.	Air at extinguishers.
18	11 min.	Hatch and main door opened, sample smoking few small embers visible at back of sample, and at center.
	13 min.	Few smoking embers at center of pile, seem to be decreasing in size.



Time

15 min. Did not rekindle.

The sample was well burned thruout.

One tenth pint of water remained in the  
extinguisher.

Soda Acid Test No. 5 Aug. 12, 1919

Freely Burning Wood Fire

Material used; 91 pieces yellow pine 2" x 2" x 2',  
1/2 gal. gasoline 58° Baume.

Weight of wood 173 lbs.

Wood arranged in thirteen tiers, seven pieces to a  
tier, weather clear, no wind. Temp. of test house  
84° F. Temp. of extinguisher 70° F.

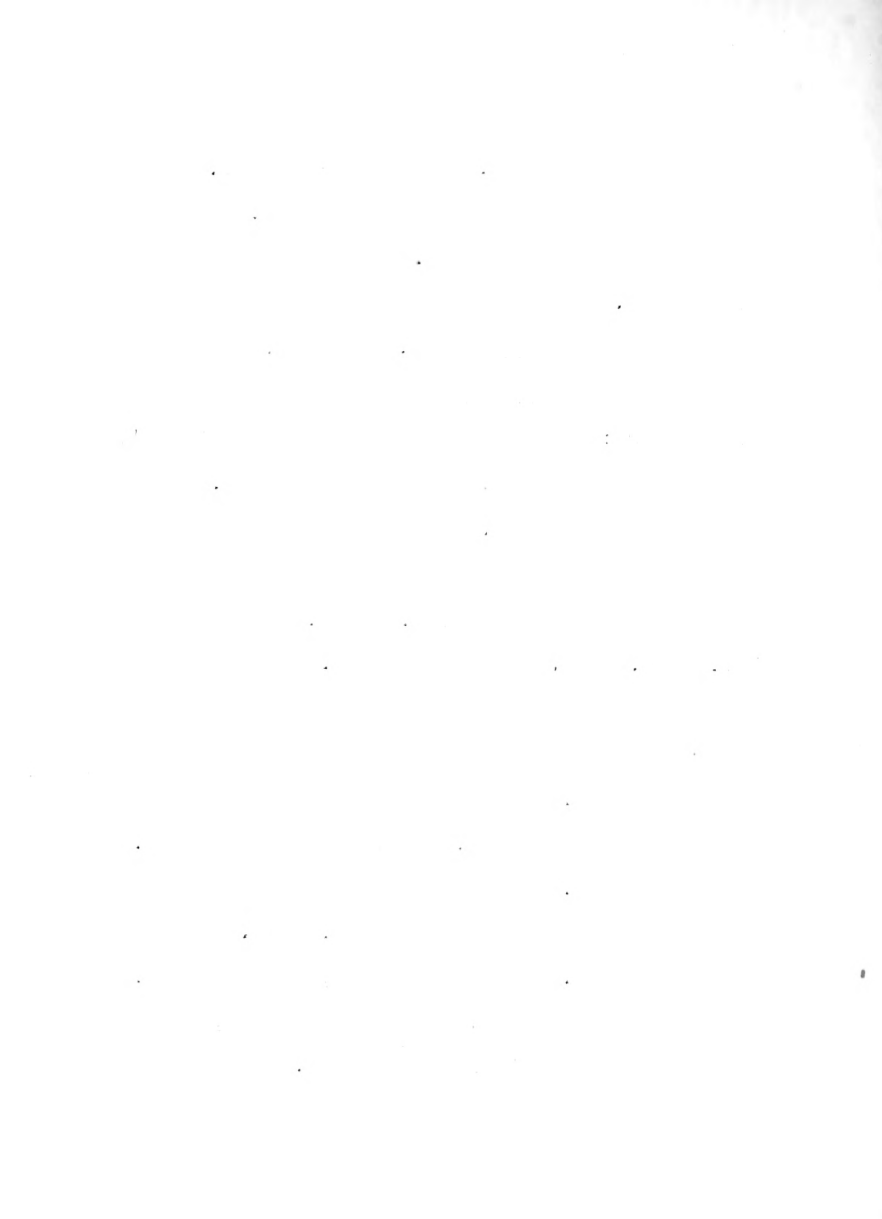
Time

0 Gasoline ignited

1 min. First four tiers afire, flame  
12 ft. high, surging to right.

2 min. First seven tiers afire, flames  
to right, 13 ft. high.

3 min. All tiers afire, flames 15 ft.  
high, draft straight up, flames  
6" from all sides.



Extinguisher  
Press

Time

	4 min.	All tiers afire, embers show on five lower tiers, few embers falling. Flames 13' high. Very little crackling.
	5 min.	Sample burning uniformly. Tongues of flames 6" from all sides. Embers on all tiers, flames 16' high.
	6 min.	Flames 16 ft. high, few embers falling.
	7 min.	Flames 17 ft. high, draft straight up, embers thruout, embers falling, slight crackling.
	8 min.	Flames 18 ft. high, heat intense many embers falling.
	9 min.	Same as for 8 min.
0	10 min.	Rear hatch and main door closed, damper opened. Soda acid extinguisher applied.
30	10 min. 5 sec.	Flames extinguished in two lower tiers, except at back of sample, flames 12 ft. high.



Extinguisher      Time  
Press.

65	10 min. 10 sec.	Flames 3 ft. high, extinguished in lower third of sample.
100	10 min. 15 sec.	Flames 3 ft. high at back fire under control
105	10 min. 20 sec.	All flames extinguished, embers visible at center of pile.
110	10 min. 25 sec.	Same.
100	10 min. 30 sec.	Small patch of embers visible at center. Smoking strongly.
95	10 min. 35 sec.	No embers visible, heavy smoke.
76	10 min. 40 sec.	Same.
68	10 min. 45 sec.	Same operator applying extinguishers close up.
62	10 min. 50 sec.	Same.
56	10 min. 55 sec.	Gas at extinguisher nozzle
38	11 min.	Operator applies extinguisher until gas is gone.





Extinguisher  
Press.

Time

- 12 min. Rear hatch and main door opened. Small embers visible at back of top tier, also at front of fourth tier.
- 13 min. Embers increase in size, also few embers show at center of pile.
- 15 min. Embers rekindled giving flame about 3" high, but went out almost immediately. Did not rekindle again.

The sample was well charred thruout. One eighth pint of solution remained in extinguisher.

Water Test No. 5 Aug. 12, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2", 1/2 gal. gasoline 58° Baume.

Weight of wood 175 lbs.

Weather clear, no wind. Temp. of test house 86° Fahr.

Temp. of extinguisher 70° F.



Time

- 0 Gasoline ignited.
- 1 min. Flames surging, 10 ft. high,  
first three tiers afire.
- 2 min. First seven tiers afire, much  
crackling. Flames straight  
up, 11 ft. high.
- 3 min. Flames off to right, 13 ft.  
high. first nine tiers afire.  
Embers on three lower tiers.
- 4 min. Gasoline out, flames straight  
up, 13 ft. high, all tiers afire,  
small embers falling.
- 5 min. Flames 13 ft. high, much crack-  
ling, large embers falling.
- 6 min. Flames 17 ft. high, embers on all  
tiers, large embers falling much  
crackling.
- 7 min. Flames 17 ft. high, heat intense.
- 8 min. Embers falling from all parts of  
pile, heat intense flames 17-18  
ft. high, all tiers ablaze.



Extinguisher Press.	Time	
0	10 min.	Main door and roof hatch closed, damper opened, water extinguisher applied.
15	10 min. 5 sec.	Flames out in lower three tiers, flames 10' high.
33	10 min. 10 sec.	Fire under control, flames 6' high.
47	10 min. 15 sec.	Flames 1 ft. high at back of pile.
55	10 min. 20 sec.	Small flames at center of sample, fighting close up to fire.
60	10 min. 25 sec.	Small flames at back of sample.
62	10 min. 30 sec.	Fire apparently out.
58	10 min. 35 sec.	No visible embers, heavy smoke.
52	10 min. 40 sec.	Same.
43	10 min. 45 sec.	Same.



Extinguisher Press	Time	
37	10 min. 50 sec.	Rekindled back of lower tier.
Air	10 min. 51 sec.	Air at extinguisher
18	11 min.	Match and main opened, sample sacking strongly.
	12 min.	Patch of embers about 6" square at back center, two lower tiers, glowing brightly.
	14 min.	Fire rekindles at back center, burning briskly, extinguisher with one pail of water.

All tiers were well burned, being deeply charred. One fourth pint of water remained in the extinguisher.





Soda Acid Test No.6

Aug. 14, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 3" x 2',

1/2 gal. gasoline 58° Baume.

Weight of wood 169.5 lbs.

Wood arranged in 13 tiers, seven pieces to a tier.

Weather clear, no wind, Temp. of test house 74° F.

Temp. of extinguisher 70° F.

Time

0 Gasoline ignited.

1 min. First five tiers afire, flames slightly to right, 10 ft. high

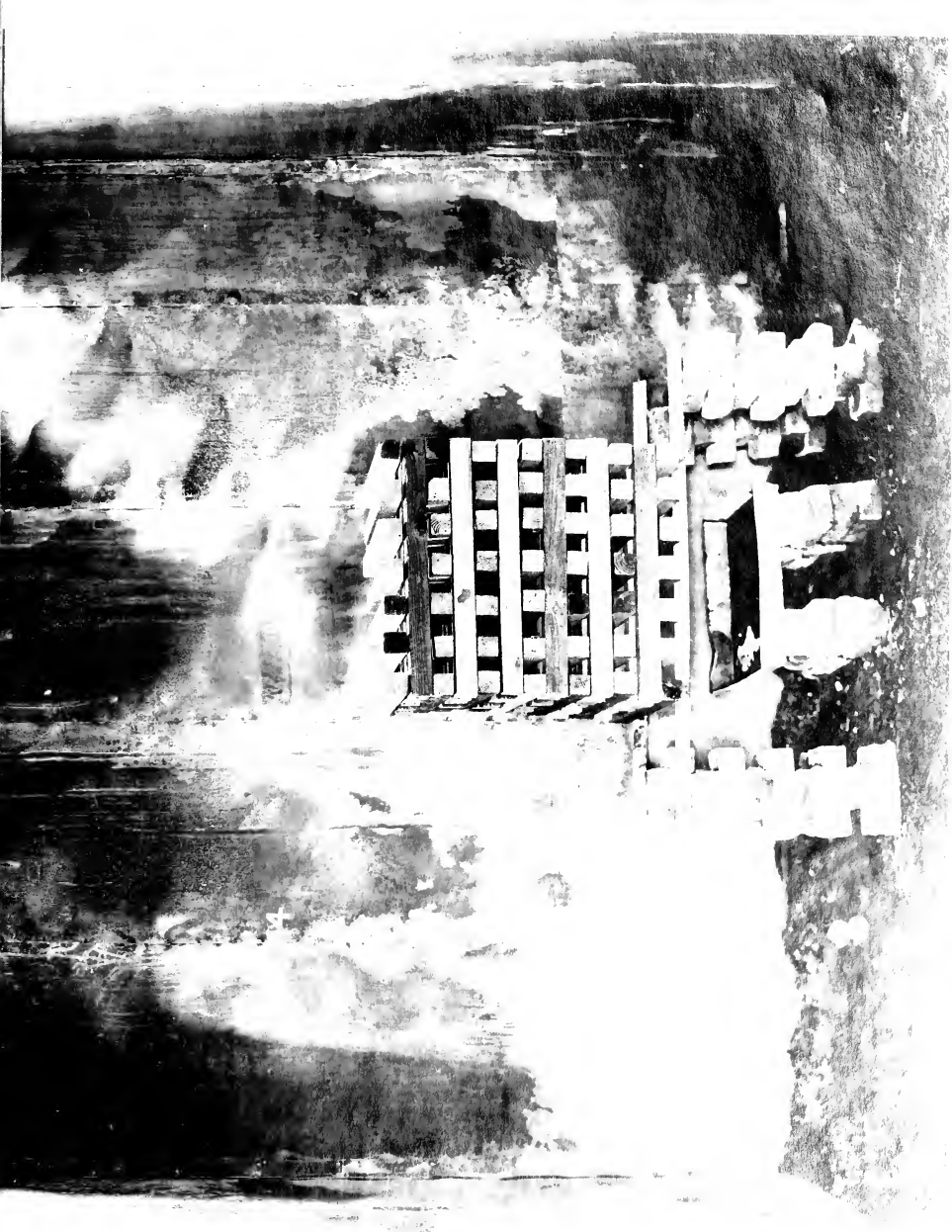
2 min. Much crackling, flames 2 ft. to right, 6" from other sides, first eight tiers afire.

3 min. All tiers afire lower half burns more strongly, flames 12ft. high, straight up, much crackling.

4 min. Gasoline out. Embers show on first ten tiers, flames 13 ft. high.

5 min. Embers falling freely, flames 17' high. Two lower tiers well charred

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Extinguisher Time  
Press.

	6 min.	Flames 17 ft. high many embers falling.
	7 min.	Burning strongly, flames 18 ft. high.
	8 min.	Many embers falling, heat intense flames 18 ft. high.
	9 min.	Sample aglow with embers, many falling, heat intense, flames 17-18 ft. high.
	10 min.	Same as before, sample burning fiercely.
	11 min.	Same as before.
0	12 min.	Rear hatch and main door closed, damper opened.
27	12 min. 5 sec.	Fire one third out, flames 8ft. high.
78	12 min. 10 sec.	Fire under control, flames 3ft. high.
104	12 min. 15 sec.	No flames visible, many embers at center of pile, fighting close up.

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Extinguisher Press	Time	
110	12 min. 20 sec.	Embers visible thruout.
113	12 min. 25 sec.	Very few embers visible.
92	12 min. 30 sec.	No embers visible on account of smoke.
80	12 min. 35 sec.	Same.
74	12 min. 40 sec.	same.
65	12 min. 45 sec.	Same, operator used ex- tinguisher until exhaus- ted.
62	13 min. 50 sec.	Same.
Gas 50	12 min. 55 sec.	Gas at extinguisher nozzle
38	13 min.	Same.
	14 min.	Hatch and main door open- ed, scattered embers thru- out sample, smoking strong- ly.
	15 min.	Fire rekindled 4th time, immediately extinguished, requiring one half gallon of water.

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The sample was well charred. The lower tiers were practically consumed. One fourth pint of liquid remained in the extinguisher.

Water Test No. 6 Aug. 14, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 3" x 3',  
1/2 gal. gasoline 58° Baume.

Weight of wood 174 lbs.

Wood arranged in 13 tiers 7 pieces to a tier.

Weather clear, no wind. Temp. of test house 79° Fahr.

Temp. of extinguisher 70° Fahr.

Time

0	Gasoline ignited.
1 min.	First six tiers afire, side draft, crackling, flames 10 ft. high.
2 min.	Flames concentrated at right back corner, tongues of flames 1 ft. from right, and 6" from other sides.
3 min.	First eleven tiers afire, embers on first five tiers, much crackling. Sample burns evenly.

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Extinguisher Press.	Time	
	4 min.	Gasoline out, embers falling freely. Much crackling, flames 15ft. high. Very slight side draft.
	5 min.	Embers show thruout sample, More in lower half. Flames 15 ft. high, embers falling
	6 min.	Same as before.
	7 min.	Flames 17 ft. high heat intense.
	8 min.	Flames 18 ft. high, all tiers show embers. Embers falling freely.
	9 min.	Same as before.
	10 min.	Large embers falling, flames 18' high.
	11 min.	Flames 16' high, sample aglow with embers, heat intense.
0	12 min.	Rear hatch and main door closed water extinguisher applied.

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Extinguisher Press.	Time	
15	12 min. 5 sec.	Flames out in front of three lower tiers, flames 10' high.
33	12 min. 10 sec.	Flames out in lower half, three feet high.
47	12 min. 15 sec.	Flames 4 ft. high, three upper tiers blazing, Under control.
55	12 min. 20 sec.	No flames visible, heavy smoke.
60	12 min. 25 sec.	Small flames at back of sample.
62	12 min. 30 sec.	No flames visible, few embers at right side.
58	12 min. 35 sec.	Same.
52	12 min. 40 sec.	No embers visible, thick smoke.
43	12 min. 45 sec.	Same.
37	12 min. 50 sec.	Same.
Air 32	12 min. 55 sec.	Air at extinguisher nozzle.
	13 min.	Heavy smoke.



Time .

14 min.	Main door and rear hatch opened, fire immediately rekindled at back of sample.
15 min.	Burning broskly. Fire extinguished with a soda and acid extinguisher.

The lower half of pile was charred all the way thru. Uperr half was well charred. One fourth pint of water remained in extinguisher.

Soda Acid Test No. 7 Aug. 14, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 2',

1/2 gal. Gasoline 58° Baume.

Weight of wood 171.5 lbs.

Wood arranged in 13 tiers, 7 pieces to a tier.

Weather clear, no wind. Temp. of test house 78° F.

Temp. of extinguisher 70° F.

Time

0 Gasoline ignited.





Time

- 1 min. First four tiers afire, flames  
10 ft. high surging.
- 2 min. First nine tiers ablaze, flames  
2 ft. to right 2" to left of  
sample. Flames 11 ft. high.
- 3 min. All tiers afire, flames straight  
up, 13' high.
- 4 min. Gasoline cut, few embers falling,  
flames 15' high, much crackling.
- 5 min. All tiers afire, many embers  
falling, flames 14ft. high.
- 6 min. Flames 17ft. high, many large  
embers falling. Many embers  
showing in all tiers.
- 7 min. Same as before.
- 8 min. Much crackling, all pieces show  
decrease in size, flames 17'  
high.
- 9 min. Large embers falling, embers of  
lower tiers decreased about  $\frac{1}{2}$   
their original size.

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Extinguisher Press	Time	
0	10 min.	Rear hatch and main door closed, soda acid extinguisher applied.
40	10 min. 5 sec.	Flames out in lower half of sample about 3' high.
70	10 min. 10 sec.	Few flames visible at back of sample.
90	10 min. 15 sec.	No flames visible, embers visible at right side and center of lower tier.
102	10 min. 20 sec.	Fire apparently out no embers visible, heavy white smoke.
102	10 min. 25 sec.	Same.
95	10 min. 30 sec.	Same. Operator continues
83	10 min. 35 sec.	Same. use of extinguisher
75	10 min. 40 sec.	Same. until pressure dis-
68	10 min. 45 sec.	Same. appears.
64	10 min. 50 sec.	Same.
Gas	10 min. 51 sec.	Gas at extinguisher nozzle.



Extinguisher  
Press.

Time

54	11 min.	Main door and rear hatch opened. Embers scattered thruout sample.
	12 min.	Sample smoking strongly.
	13 min.	Embers increasing in size and brightened.
	15 min.	Rekindles, extinguished with a pail of water.

Sample was well charred thruout. One fourth pint  
of liquid remained in the extinguisher.

Water Test No. 7

Aug. 14, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 2ft.

1/2 gal. gasoline 58° Baume.

Weight of wood 170 lbs.

Wood arranged in 13 tiers, 7 pieces to a tier.

Weather clear, no wind, Temp. of test house 80° F.

Temp. of extinguisher 70° F.

Time

0 Gasoline ignited.

1 min. Flames 10 ft. straight up, high,



Time	first six tiers afire.
2 min.	Flames 10 ft. high, much crackling, surging first nine tiers afire.
3 min.	Flames 12 ft. high, all tiers afire, three lower tiers show embers. Flames 6in. from all sides.
4 min.	Gasoline out. Many embers falling, flames 15ft. high, draft straight up.
5 min.	Many embers falling, embers show thruout sample. Flames 16ft. high. much crackling.
6 min.	Flames 17ft. high, many embers falling, much crackling. Lower two tiers well burned.
7 min.	Same as before.
8 min.	Flames 17ft. sample aglow with embers, many falling.
9 min.	Same as before.





Extinguisher Press	Time	
0	10 min.	Rear hatch and main door closed, water extinguisher applied.
15	10 min. 5 sec.	Flames out in three lower tiers, 10 ft. high.
33	10 min. 10 sec.	Flames 6 ft. high at back of sample.
47	10 min. 15 sec.	Flames under control. Few flames visible at back of sample.
55	10 min. 20 sec.	Few flames visible at right back corner.
60	10 min. 25 sec.	No flames visible. Few embers visible at right side of sample.
62	10 min. 30 sec.	Same, heavy smoke.
58	10 min. 35 sec.	Same.
52	10 min. 40 sec.	Embers visible at bottom of sample.
43	10 min. 45 sec.	Same.



Extinguisher Press	Time	
37	10 min. 50 sec.	Same.
Air	10 min. 51 sec.	Air at extinguisher.
	11 min.	Rear hatch and main door opened.
	12 min.	Half of two lower tiers full of embers, rekindling
	13 min.	Rekindled in 3 lower tiers at back center, blaze increasing in size. Flames extinguished with pail of water.

Sample was well charred thruout. One fourth pint of water in the extinguisher.

Soda Acid Test No. 8 Aug. 15, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 3'.

1/2 gal. gasoline 58° Baume.

Weight of wood 171 lbs.

Wood arranged in 13 tiers, seven pieces to a tier.

Weather clear, slight wind. Temp. of test house 70° F.



Temp. of extinguisher 700 F. Wood contained much pitch.

Time

- 0 Gasoline ignited.
- 1 min. Flames 10 ft. high, four lower tiers afire.
- 2 min. First seven tiers afire, flames off to right, 12 ft. high.
- 3 min. First ten tiers afire. Flames 12ft. high, draft straight up, embers in lower third of sample.
- 4 min. Gasoline out. Many embers falling, much crackling, flames 14 ft. high.
- 5 min. All tiers afire, embers show in lower half of sample, many falling, much crackling, flames 14 ft. high.
- 6 min. Flames 15ft. high, embers falling freely.
- 7 min. Four lower tiers well burned, flames 17 ft. high.
- 8 min. Large embres falling, flames 17'high.



Extinguisher Time  
Press.

	9 min.	Heat intense, embers thruout sample, many falling, flames 17' high.
0	10 min.	Main door and rear hatch closed, damper opened. Soda acid extinguisher applied.
25	10 min 5 sec.	Flames out in lower half, 8 ft. high.
64	10 min. 10 sec.	Under control, 3ft. high at back of sample.
72	10 min. 15 sec.	Flames 1 ft. high at left of sample.
102	10 min. 20 sec.	Flames all out, embers visible thruout sample.
98	10 min. 25 sec.	Embers visible lower tier.
88	10 min. 30 sec.	Embers visible two lower tiers.
81	10 min. 35 sec.	No embers visible, heavy white smoke.
74	10 min. 40 sec.	Same.
68	10 min. 45 sec.	Same.
62	10 min. 50 sec.	Same.





Extinguisher Press	Time	
Gas	10 min. 53 sec.	Gas at extinguisher nozzle. Operator applies extinguisher until pressure is exhausted.
32	11 min.	Rear hatch and main door opened. Small embers visible thruout sample.
	12 min.	Sample smoking strongly.
	15 min.	Fire rekindles at center of pile, extinguished with pail of water.

Sample was well burned thruout. One eighth pint  
of liquid remained in the extinguisher.

Water Test No. 8      Aug. 15, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 2',  
1/2 gal. gasoline 58° Baume.

Weight of wood 169 lbs.

Wood arranged in 13 tiers, 7 pieces to a tier. Wood  
contained much pitch. Temp. of test house 75° F. Temp.  
of extinguisher 70° F.

Weather clear, slight wind.



Time	
0	Gasoline ignited.
1 min.	Flames 10 ft. high, strong side draft.
2 min.	Flames off to right, 17ft. high, very strong draft, first 9 tiers afire.
3 min.	All tiers afire, flames 12' high, gasoline nearly out, burned out at 3 min. 35 sec.
4 min.	Much crackling, many falling embers embers showing on eight lower tiers Flames 14ft. high.
5 min.	Flames 15ft. high, much crackling, many large embers falling. Embers show on all tiers.
6 min.	Flames straight up 17ft. high.
7 min.	Four lower tiers well burned away, much crackling. Flames 17' high.
8 min.	Very strong draft, flames 17' high.
Extinguisher Press 0	10 min. Main door and rear hatch closed, damper opened. water extgr. applied



Extinguisher Press.	Time	
	10 min. 5 sec.	Flames out in lower tier, flames 8 ft. high.
	10 min. 10 sec.	Flames out at front of sample, 3 ft. high at back.
	10 min. 15 sec.	Flames 1 ft. high in back, fire under control.
55	10 min. 20 sec.	Flames visible at lower right.
60	10 min. 25 sec.	Small flames visible at back right corner.
62	10 min. 30 sec.	No flames visible, white smoke.
58	10 min. 35 sec.	Embers visible at back right corner.
52	10 min. 40 sec.	No embers visible, white smoke.
43	10 min. 45 sec.	Same.
37	10 min. 50 sec.	Same.
Air	10 min. 51 sec.	Air at extinguisher nozzle.
18	11 min.	Rear hatch and main door open- ed. Embers visible thru cut sample.



Time

12 min.      Rekindled at back center,  
                 flames 2" high.  
13 min.      Flames went out.  
15 min.      Flames rekindled again in two  
                 lower tiers, increasing in size,  
                 extinguished with half a gallon  
                 of water.

Sample was well burned away in lower third. Remain-  
der well charred. One fourth pint of water remained in  
the extinguisher.

Soda Acid Test No.9

Aug. 15, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 2',  
                 1/2 gal. gasoline 58° Baume.

Weight of wood 172 lbs.

Wood contained much pitch. Wood arranged in 13 tiers,  
7 pieces to a tier. Weather clear, light breeze. Temp.  
of test house 74° F. Temp. of extinguisher 70° F.

Time

0      Gasoline ignited.  
1 min.      First four tiers afire, flames 11'  
                 high, flames off to right.

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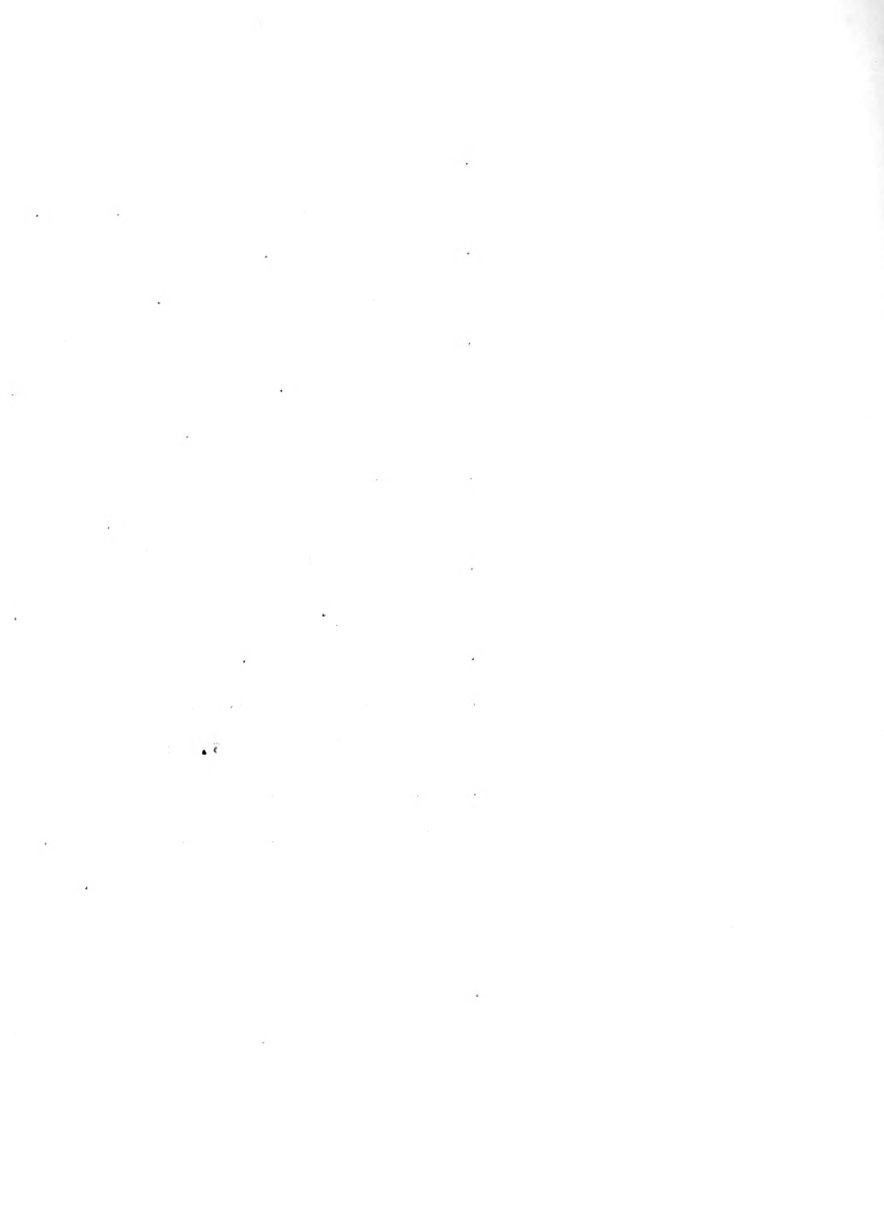


Time

- 2 min. First seven tiers afire, much crackling, flames 11 ft. high.
- 3 min. Flames 11 ft. high, much crackling, flames surging.
- 4 min. All tiers afire, burning evenly, flames 13ft. high, gasoline cut. Few embers falling.
- 5 min. Embers show thruout sample, many falling, flames 14' high.
- 6 min. Flames 15' high, sample burning strongly, embers falling freely.
- 7 min. Same as before.
- 8 min. Flames 16-17 ft. high, sample aglow with embers. Many falling
- 9 min. Heat intense, much crackling, strong draft, flames 13-17 ft. high, large embers falling.

Extinguisher  
Press

- O 10 min. Rear hatch and main door closed, damper opened.



Extinguisher Press	Time	
20	10 min. 25 sec.	Flames 8ft. high
55	10 min. 10 sec.	Flames out in lower half, flames 2' high, fire under control.
75	10 min. 15 sec.	Small flames visible at back.
100	10 min. 25 sec.	No flames visible. Embers in lower half of sample, white smoke.
100	10 min. 35 sec.	Fire apparently out, no embers visible. Dense smoke.
94	10 min. 30 sec.	Same.
78	10 min. 35 sec.	Same.
70	10 min. 40 sec.	Same.
65	10 min. 45 sec.	Same.
60 gas	10 min. 47 sec.	Gas at extinguisher noz- zle. Extinguisher was applied until pressure was exhausted.



Extinguisher  
Press

Time

11 min.

Rear hatch and main  
door opened. Fire  
immediately rekindled  
at back center, and  
front, lower tiers,  
flames one ft. high.

12 min.

Burning briskly.  
Flames extinguished  
with fire hose.

The sample was practically consumed in the lower half, the remainder being well burned. One fourth pint of solution remained in the extinguisher.

Water Test No.9

Aug. 15, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 3" x 3" x 2'

1/2 gal. gasoline 58° Baume.

Weight of wood 170 lbs. Wood contained much pitch.  
Wood arranged in 13 tiers, 7 pieces to a tier. Temp.  
of test house 76° F. Temp. of extinguisher 70° F.  
Weather clear, slight wind.



Time	
0	Gasoline ignited.
1 min.	First four tiers afire, flames 11 ft. high, surging to right.
2 min.	First nine tiers afire, flames 12 ft. high, embers on three lower tiers, much crackling.
3 min.	All tiers afire. Flames off to right, 14 ft. high.
4 min.	Gasoline out. Sample burning evenly, few embers falling, much crackling.
5 min.	Flames 13 ft. high. Embers showing thruout sample, many falling. Flames 6" from all sides of sample.
6 min.	Sample burning strongly thru- out, many embers falling. Flames 16 ft. high.
7 min.	Same as before.
8 min.	Flames 17 ft. high. Embers show thruout sample, many falling. Much crackling.





Extinguisher Press	Time	
	9 min.	Draft very strong. Flames 17' high. Sam- ple aglow with embers. Heat intense.
0	10	Rear hatch and main door closed, damper opened. Water extinguisher applied.
15	10 min. 5 sec.	Flames out in lower fourth of sample. Flames 10 ' high.
33	10 min. 10 sec.	Flames 8' high. Fire out in lower half of sample.
47	10 min. 15 sec.	Fire under control. Flames 2ft. high at back of sam- ple.
55	10 min. 30 sec.	Few flames visible at back right corner of sample.
60	10 min. 25 sec.	Flames all out, heavy smoke
62	10 min. 30 sec.	Embers visible in lower part of sample.



Extinguisher Press	Time	
58	10 min. 35 sec.	Smoke very thick. Few scattered embers visible.
52	10 min. 40 sec.	Same.
43	10 min. 45 sec.	Same.
37 Air	10 min. 50 sec.	Air at extinguisher nozzle.
	11 min.	Main door and rear hatch opened. Large embers on back of sam- ple. Small embers scattered thruout sam- ple. Sample smoking strongly.
	12 min.	Smoking more strongly, embers grow brighter.
	13 min.	Same.
	14 min.	Rekindled at back right corner of sample. Fire extinguished with pail of water.



The lower half of sample was practically consumed, the remainder being well burned. One fourth pint of water remained in the extinguisher.

Soda Acid Test No. 10

Aug. 18, 1919.

Freely Burning Wood Fire

Material used: 91 pieces yellow pine 2" x 2" x 2',

1/2 gal. gasoline 58° Baume.

Weight of wood 172 lbs. Wood arranged in 13 tiers, seven pieces to a tier. Temp. of test house 80° F.

Temp. of extinguisher 70° F. Weather clear, no wind.

Time

0 Gasoline ignited.

1 min. First three tiers afire. Flames off to right. Sample not burning on left side. Evidence of side draft. Flames 10 ft. high.

2 min. First six tiers afire. Flames 1 ft. from right side, 6" from left. Flames 10 ft. high.

3 min. First nine tiers afire. Sample burning evenly. Flames 10 ft. high.



Extinguisher  
Press.

Time

- 4 min. All tiers afire. Embers show on lower tiers. Flames 12 ft. high.
- 5 min. Sample burning evenly. Five lower tiers show embers. Flames 15' high.
- 6 min. Eight lower tiers show embers, very few falling.
- 7 min. Flames 16ft. high. All tiers show embers. Few embers falling. Much crackling.
- 8 min. First eight tiers show embers all over. Flames 16' high.
- 9 min. Few large embers falling, flames 10' high.
- 10 min. Main door and rear hatch closed, damper opened. Soda acid extinguisher applied.





Extinguisher Press.	Time	
43	10 min. 5 sec.	Flames 7 ft. high. Fire out in lower half of sam- ple.
69	10 min. 10 sec.	Flames 4 ft. high. Fire out in lower three fourths of sample, Fire under con- trol.
96	10 min. 15 sec.	No flames visible. Embers visible thruout.sample.
104	10 min. 20 sec.	Embers visible at back center. Heavy white smoke.
102	10 min. 25 sec.	Embers visible at center and at right of sample.
94	10 min. 30 sec.	Same.
84	10 min. 35 sec.	Small embers thruout.
75	10 min. 40 sec.	Same.
68	10 min. 45 sec.	Small embers thruout, large patch at center of sample.
63 Gas	10 min 50 sec.	Gas at extinguisher nozzle. Operator applies extinguisher until pressure is exhausted.



Extinguisher Press.	Time	
35	11 min.	Rear hatch and main door opened. Small embers scattered thruout sample. Sample smoking strongly.
	12 min.	Same.
	13 min.	Embers increasing in size.
	14 min.	Same.
	15 min.	Rekindled, but flames again went out.
	20 min.	Rekindled, and blazed strongly at center pile.

The sample was well burned thruout. Members of all tiers were deeply charred. One fourth pint of liquid remained in the extinguisher.

Water Test No. 10 Aug. 13, 1919.

Freely Burning Wood Fire.

Material used: 91 pieces yellow pine 2" x 2" x 2',

1/2 gal. gasoline, 58° Baume.

Weight of wood 171 lbs. Wood arranged in 13 tiers,

7 pieces to a tier. Temp. of test house 78° F. Temp.

of extinguisher 70° F. Weather clear, no wind.



Time	
0	Gasoline ignited.
1 min.	First six tiers afire. Flames off to right. Evidence of side draft. Flames 10 ft. high.
2 min.	First ten tiers afire, much crackling. Flames 13 ft. high. Embers show- ing on three lower tiers.
3 min.	Much crackling, many embers falling. All tiers afire. Embers on five lower tiers, flames 13' high.
4 min.	Sample burning evenly. Flames straight up. Embers thruout lower half of sample. Flames 16' high.
5 min.	Many embers falling. Embers show thruout sample. Gasoline out. Flames 17' high.



Extinguisher  
Press.

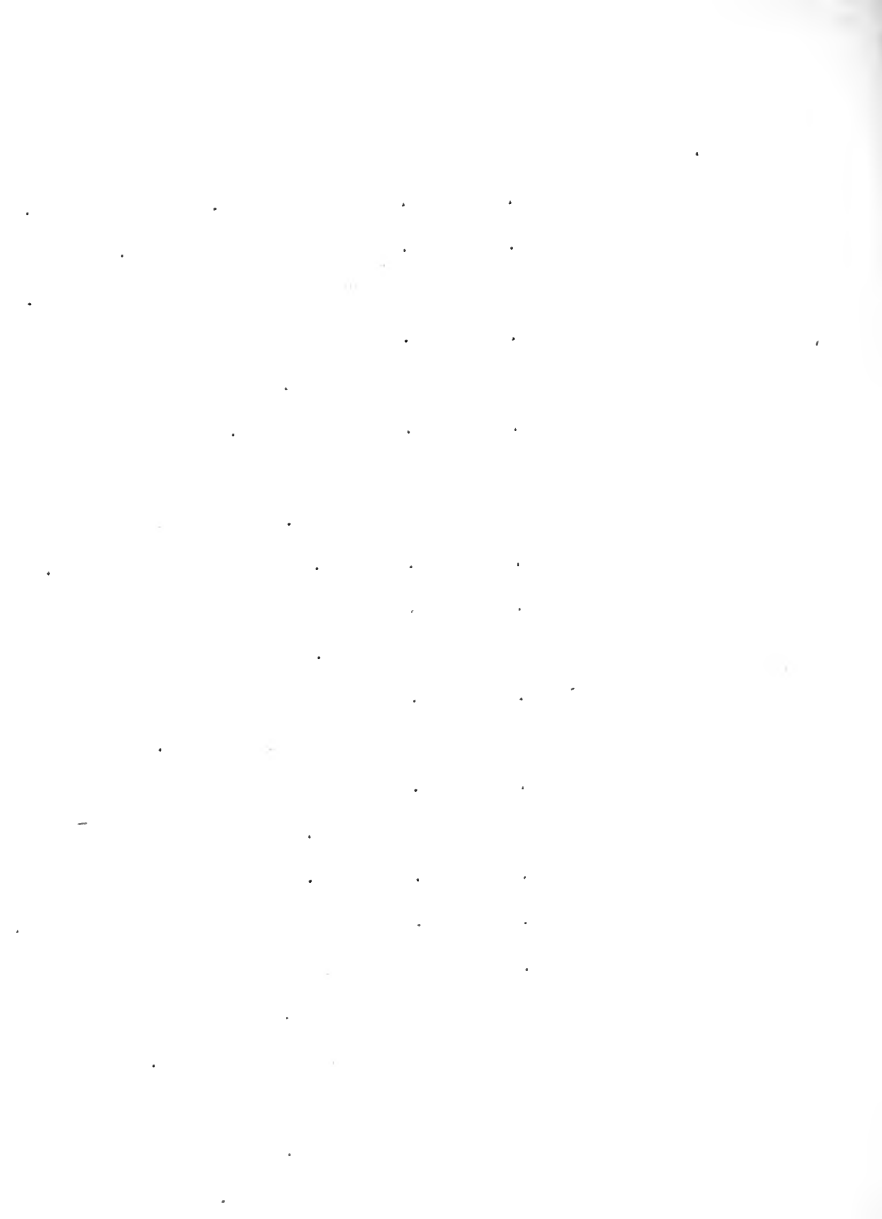
Time

	6 min.	Flames 17 ft. high straight up. Many large embers falling.
	7 min.	Same as before.
	8 min.	Flames straight up. Sample burning strongly thruout. Many embers falling. Lower tiers half burned. Flames 13' high.
	9 min.	Flames 13' high. Sample aglow with embers. Heat intense.
0	10 min.	Main door and rear hatch closed, damper opened, Water extinguisher applied.
15	10 min. 5 sec.	Fire out in front of sample. Flames 5' high in rear of sample.





Extinguisher Press.	Time	
33	10 min. 10 sec.	Flames 4 ft. high in back.
47	10 min. 15 sec.	Fire under control. Flames 1' high at left of sample.
55	10 min. 20 sec.	Small flames visible , back center.
60	10 min. 25 sec.	Flames out. Embers visible at right side and on top of sample.
62	10 min. 30 sec.	Same. Heavy white smoke.
58	10 min. 35 sec.	Embers visible on top tier.
52	10 min. 40 sec.	Few embers visible, at right of sample.
43	10 min. 45 sec.	Few embers visible, bottom tier.
37	10 min. 50 sec.	Same.
Air	10 min. 51 sec.	Air at extinguisher nozzle.
	11 min.	Rear hatch and main door opened. Large embers at center of sample. Small embers scattered thruout sample. Large embers on bottom tier.



Time	
12 min.	Embers increasing in brightness. Sample smoking strongly.
15 min.	Embers apparently Going out. Did not rekindle. Rekindled at center of sample, flames about 3" high. However they spread rapidly, and burned briskly. Fire extinguished with pail of water.

The sample was well burned thruout. One fourth pint of liquid remained in the extinguisher.



## C O N C L U S I O N S

### Water Test No. 1 vs. Soda Acid No.1

The fire for the water test did not seem to burn as strongly as for the soda test. More embers were falling for the soda acid test, at the time when the extinguisher was applied. The soda acid extinguisher showed a superiority in controlling the fire, also a slight superiority in extinguishing the embers.

### Water Test No. 2 vs. Soda Acid Test No.2

The condition of the fires was the same at the time when the extinguishers were applied. The soda acid extinguisher controlled the fire five seconds sooner than did the water extinguisher. The water extinguisher showed a slight superiority in extinguishing embers.

### Water Test No.3 vs Soda Acid Test No.3

The fire for the soda acid test was much larger than for the water test, the flames being much higher, and the heat more intense. Both extinguishers controlled the fire within fifteen seconds. The soda acid extinguisher shows a superiority in controlling the fire, otherwise their efficiencies were about the same.



#### Water Test No.4 vs. Soda Acid Test No.4

The fire for the water test was slightly larger than for the soda acid test. More embers were falling at the time when the extinguisher was applied. The flames were controlled more easily with the soda acid extinguisher, and it was possible for the operator to advance to 5ft. at the end of five seconds. For the water test, the operator was unable to move up to 5 ft. until after ten seconds. The extinguishing efficiencies were practically the same.

#### Water Test No.5vs. Soda Acid Test No.5

The condition of the fires was about the same for both tests. The soda acid extinguisher showed a slight superiority in controlling the fire. The soda acid extinguisher showed also a superiority in extinguishing the fire.

#### Water Test No.6 vs. Soda Acid Test No.6

The soda acid extinguisher controlled the fire more easily. It showed a better efficiency in extinguishing the fire, although neither extinguisher completely put out the fire.





Water Test No.7 vs. Soda Acid Test No.7

The soda acid extinguisher controlled the fire more easily, but the extinguishing efficiencies were the same.

Water Test No.8 vs. Soda Acid Test No.8

The condition of the fire was the same when the extinguishers were applied. The soda acid extinguisher controlled the fire more easily, but the extinguishing efficiencies were practically the same.

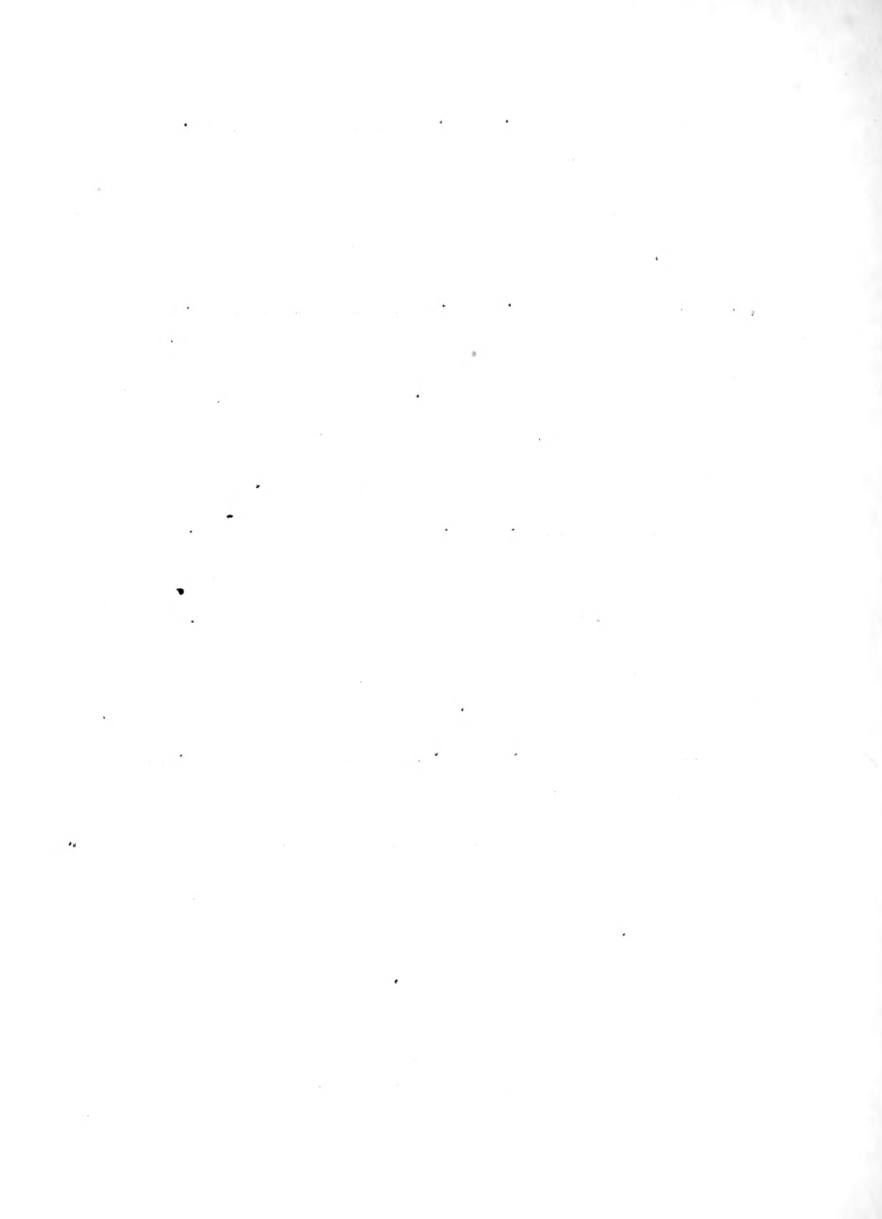
Water Test No.9 vs. Soda Acid Test No.9

The soda acid extinguisher controlled the fire more easily than did the water extinguisher. The water extinguisher showed a very slight superiority in extinguishing embers.

Water Test No.10 vs. Soda Acid Test No.10

The fire for the water test was much larger than for the soda acid test, due to a difference in draft.

The soda acid extinguisher controlled the fire more easily. There was no noticeable difference in the extinguishing efficiency.



For the conditions under which the tests were conducted, the soda acid extinguisher shows a superiority over the water extinguisher in controlling the fires. This is due first to the stronger stream from the soda acid extinguisher, and second to the greater area covered by the stream. The stream from the soda acid extinguisher seems to be more effective in extinguishing flames, as the stream is very finely divided by the gas generated in the extinguisher. The stream from the soda acid extinguisher seems to be more effective in extinguishing embers.

as to the extinguishing properties of the  $\text{CO}_2$  gas generated in the extinguisher, no definite conclusions could be drawn.

